

**SpectraLineHandy – the Multipurpose
Gamma-Spectrometry Software Package
for Nuclear and Radioactive Materials
Control with HPGe, CZT, LaBr(CI) –
Detectors.**

**Danilenko V.N., Kovalsky E.A.,
Kuznetsov V.P., Skubo J.V., Solovyeva S.L.,
Fedorovsky S.J., Juferov A.J.**



**LABORATORY
of spectrometry
and radiometry**

**<http://www.lsrn.ru>
mail: lsrn@lsrn.ru
Phone: +7 495 660-16-14**

The main activity of LSRM Ltd. is the development of software, methodical and metrology for ionizing radiation measurements:

- Software packages for α -, β - и γ -radiation semiconductor and scintillation spectrometers:
 - The certified measurements
 - Detection and identification of the fissionable and radioactive materials
 - Radiation monitoring
- Our own methodologies for measurements
- Databases with radioactive decay parameters
- Our own algorithms and methods for calculation of ionizing radiation characteristics, including modeling of gamma spectra of various detectors

Nuclide Master- Database with radioactive decays parameters

New File Nuclide Calculate factors Additional Help

Find nuclide

Nuclide	Half-life
Ac-229	62.7(min) ±5.0E-1
Ag-103	65.7(min) ±7.0E-1
Ag-104	69.2(min) ±1.0E+0
Ag-105	41.29(day) ±7.0E-2
Ag-106M	8.28(day) ±2.0E-2
Ag-107	Stable
Ag-108M	418.0(year) ±2.1E+1
Ag-109	Stable
Ag-110M	249.76(day) ±4.0E-2
Ag-111	7.45(day) ±1.0E-2
Ag-112	3.13(hour) ±9.0E-3
Ag-113	5.37(hour) ±5.0E-2
Al-26	7.2E+05(year) ±2.4E+1
Al-27	Stable
Al-33	Stable
Am-237	73.0(min) ±1.0E+0
Am-238	98.0(min) ±2.0E+0
Am-239	11.9(hour) ±1.0E-1
Am-240	50.8(hour) ±3.0E-1
Am-241	432.2(year) ±7.0E-1
Am-242	16.02(hour) ±2.0E-2
Am-242M	141.0(year) ±2.0E+0

Name U
 A= 235
 Z= 92
 T>= 1.0E+0 hours
 Stable nuclides
 Metastable nuclides
 Nuclides with no data
 Show nuclide name

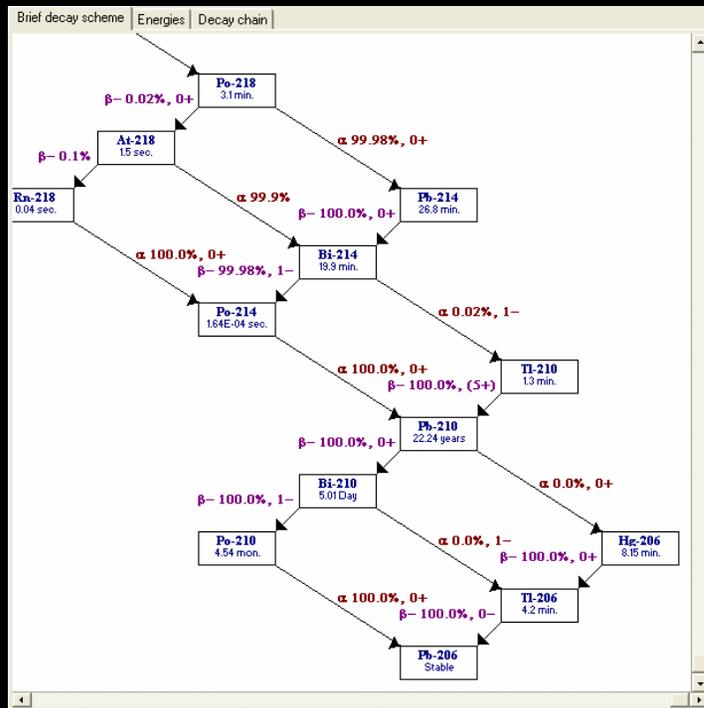
Energy	Energy abs. error	Intensity	Intensity abs...	Lin
U-238	4.5E+09(y...	0.00028523		
49.55	6.0000E-02	6.4000E-02	8.0000E-03	
113.5	1.0000E-01	1.0200E-02	1.5000E-03	
U-235	7.0E+08(y...	2.5758		
13		3.6000E+01	4.0000E+00	
19.59	1.0000E-02	0.0000E+00		
31.6	5.0000E-02	1.6000E-02	5.0000E-03	
34.7	1.0000E-01	3.7000E-02	AP	
41.4	3.0000E-01	3.0000E-02	2.0000E-02	
41.96	1.5000E-01	6.0000E-02	1.0000E-02	
51.22	1.0000E-01	2.0000E-02	1.5000E-02	
54.1	1.0000E-01	2.0000E-03	LT	
54.25	5.0000E-02	3.0000E-02	LE	
60.5	1.0000E-01	0.0000E+00		
64.37	2.0000E-02	4.0000E-02	AP	
72.7	2.0000E-01	1.1000E-01	AP	
75.02	5.0000E-02	6.0000E-02	1.0000E-02	
89.953	2.0000E-03	3.5600E+00	7.0000E-02	
93.35	2.0000E-03	5.8100E+00	1.1000E-01	
94	5.0000E+00	0.0000E+00		
95.7	1.0000E-01	0.0000E+00		
96.09	2.0000E-02	8.6000E-02	1.1000E-02	
105		2.6900E+00	7.0000E-02	
109.16	2.0000E-02	1.5400E+00	5.0000E-02	
115.45	5.0000E-02	7.0000E-02	4.0000E-02	
120.35	5.0000E-02	2.6000E-02	AP	
136.55	5.0000E-02	1.2000E-02	AP	
140.76	4.0000E-02	2.2000E-01	2.0000E-02	
142.4	5.0000E-02	5.0000E-03	AP	
143.76	2.0000E-02	1.0960E+01	8.0000E-02	
147	1.0000E-01	0.0000E+00		
150.93	2.0000E-02	7.6000E-02	1.0000E-02	
163.33	2.0000E-02	5.0800E+00	4.0000E-02	
173.3	1.0000E+00	1.0000E-02	5.0000E-03	

Energy <= 4.0E+1
 Energy >= 1.0E+3
 Intensity [% of line with max yield]
 I>= 1.0E+0 %
 I<= 1.0E+2 %
 Intensity [absolute values]
 I>= 0.0E+0
 I<= 1.0E+3
 Color of intensive lines:
 Display data in metrological format
 Merge lines for nuclide with
 IDWin for 122 keV 1.0E+0
 IDWin for 1332 keV 2.2E+0
 Check data before library saving
 Lines with equal energies
 Lines with zero yields
 Data in ENSDF-format

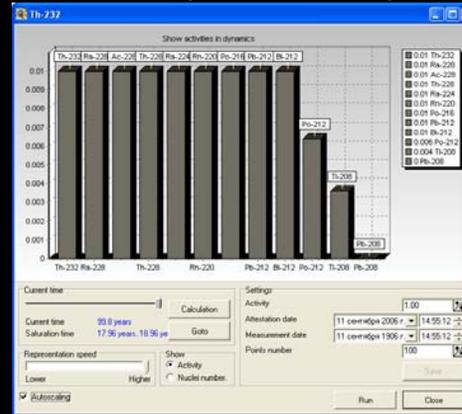
Nuclide Master- Database with radioactive decays parameters

with user-friendly GUI

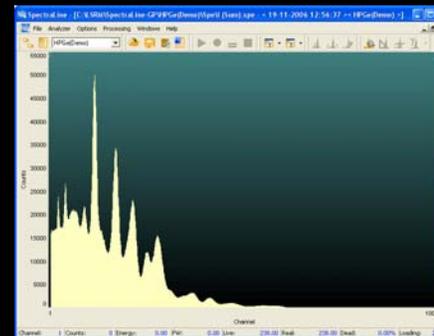
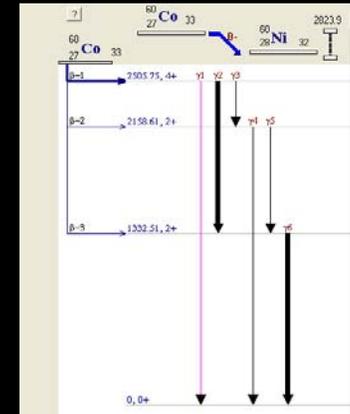
viewing of the decay chain



display a change of the nuclides activity by a decay chain dynamically



viewing of decay schemes of the required nuclide



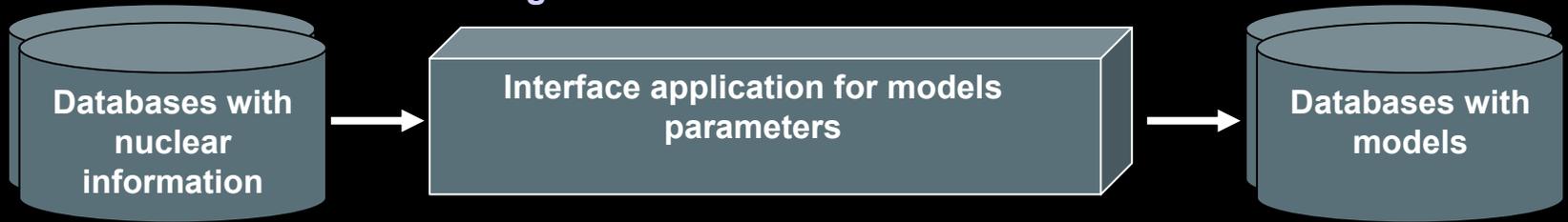
generation of gamma-spectra

GammaLab – integrated system of nuclear data, computation applications and spectra processing programs for gamma spectrometry experiments modeling and emulation

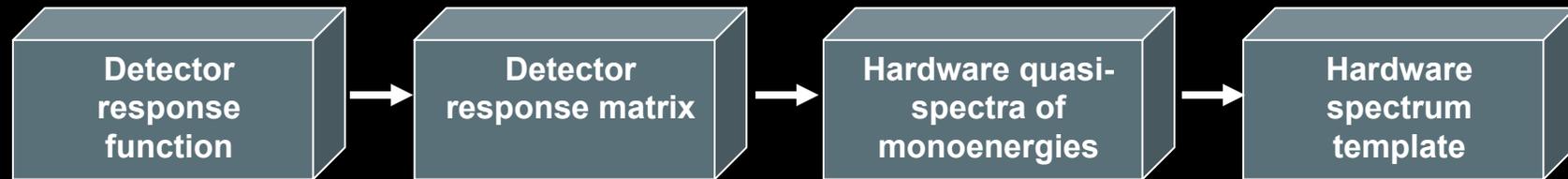
The system models the measurements with semiconductor and scintillation spectrometers. Monte-Carlo method, evaluated nuclear structure data files ENSDF and cross sections are used for calculation. The following aspects are taken into consideration:

- radionuclides mixture and activity,
- shipping container,
- position of detector and source,
- radioactive background,
- hardware influence (peaks widening and shift, errors depending on the loading etc.)

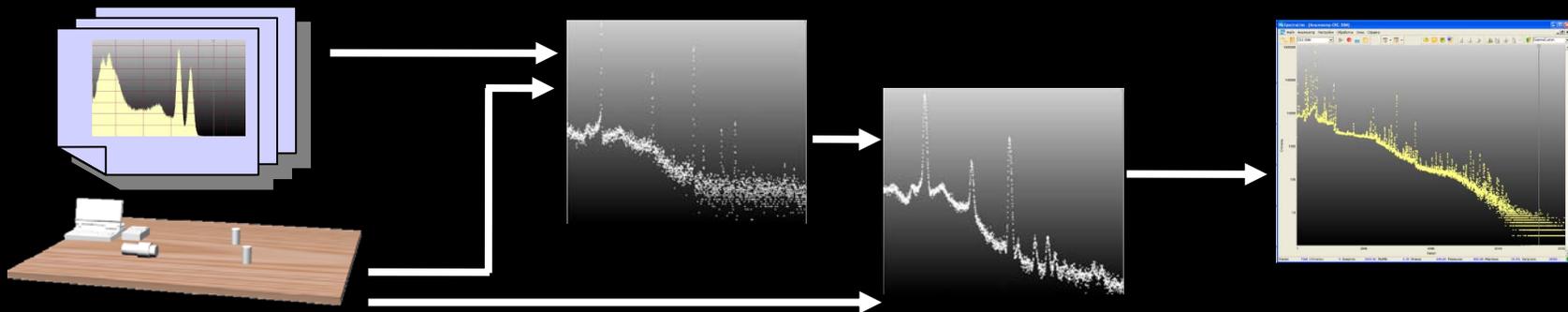
Sources and Hardware Modelling



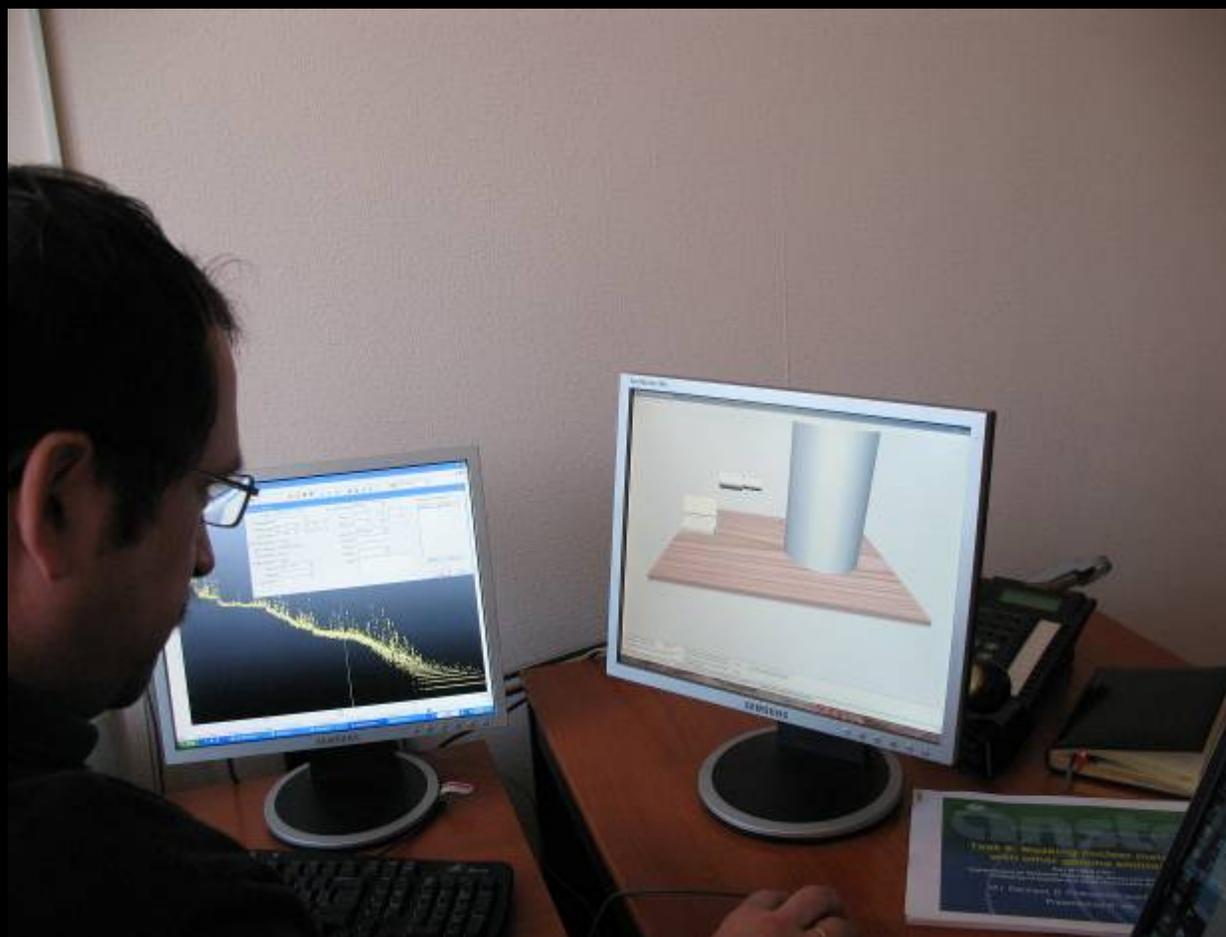
Calculation of Spectra Templates for Sources with the Required Radionuclides Mixture



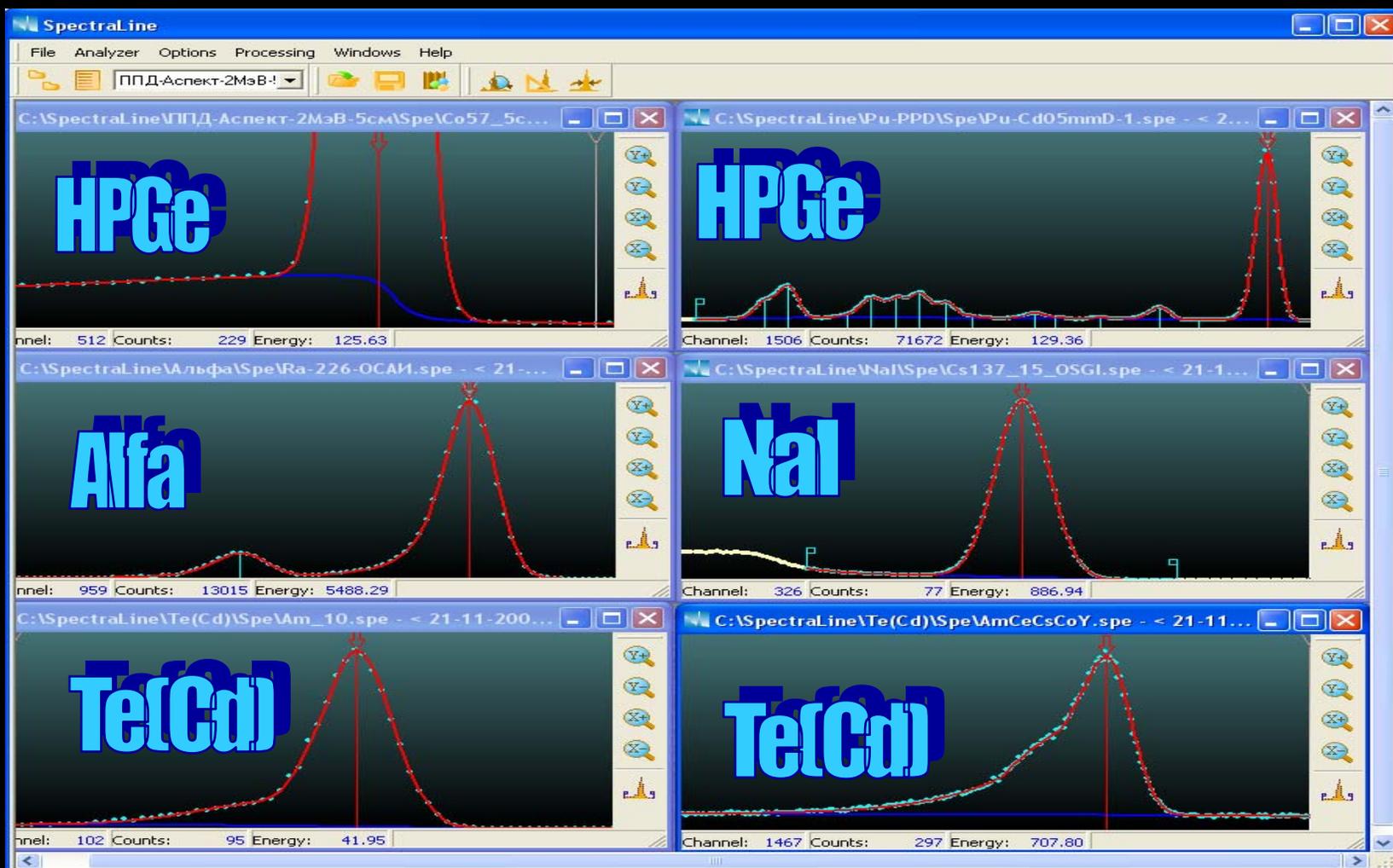
Spectra Emulation in the Real-time Operation Mode, Using Processing Software



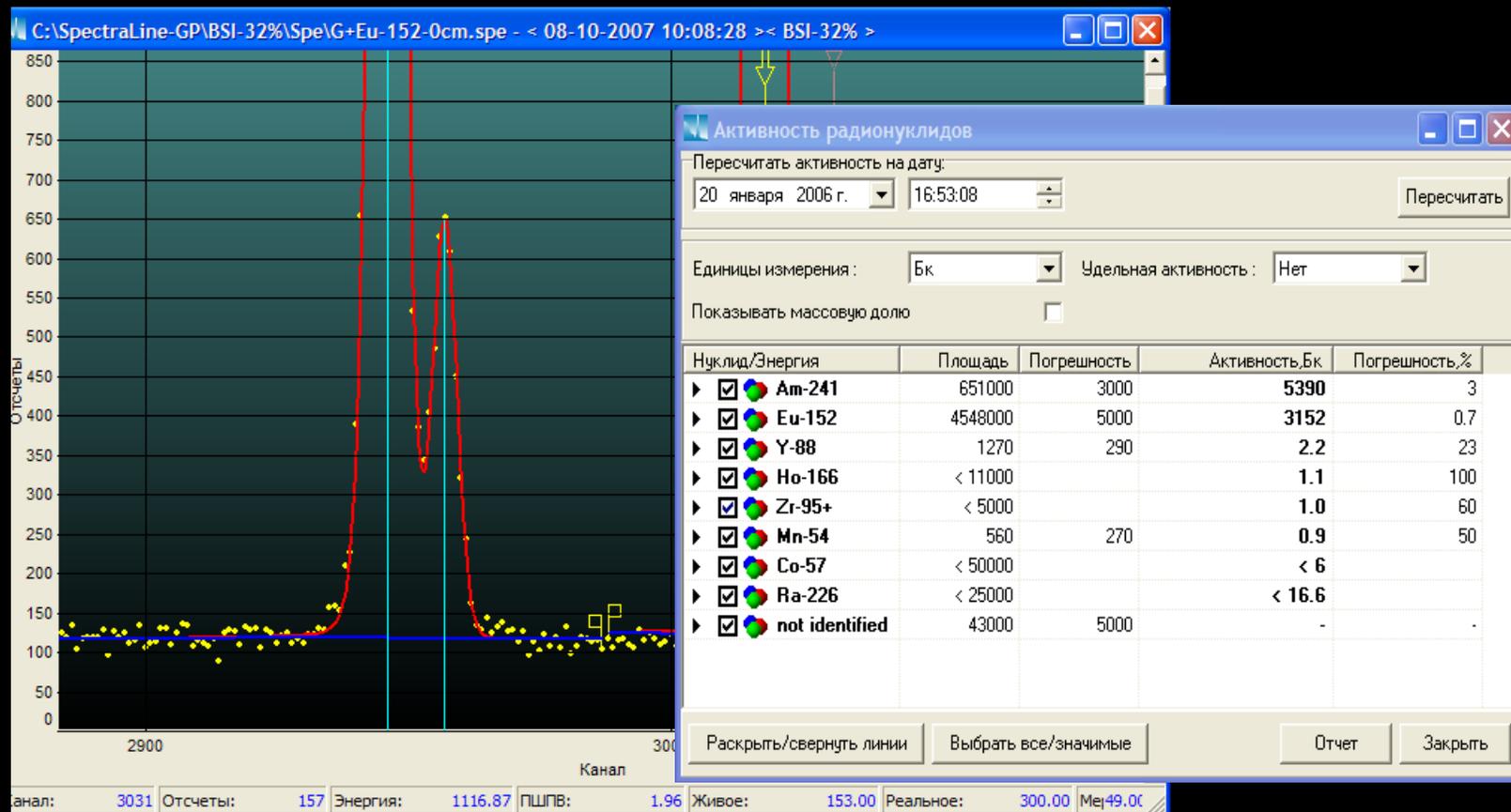
«Trainer»- software package is used to obtain practical experience for customs inspection of fissionable and radioactive materials .



SpectraLine – Software Products Family for Linear Spectra Processing

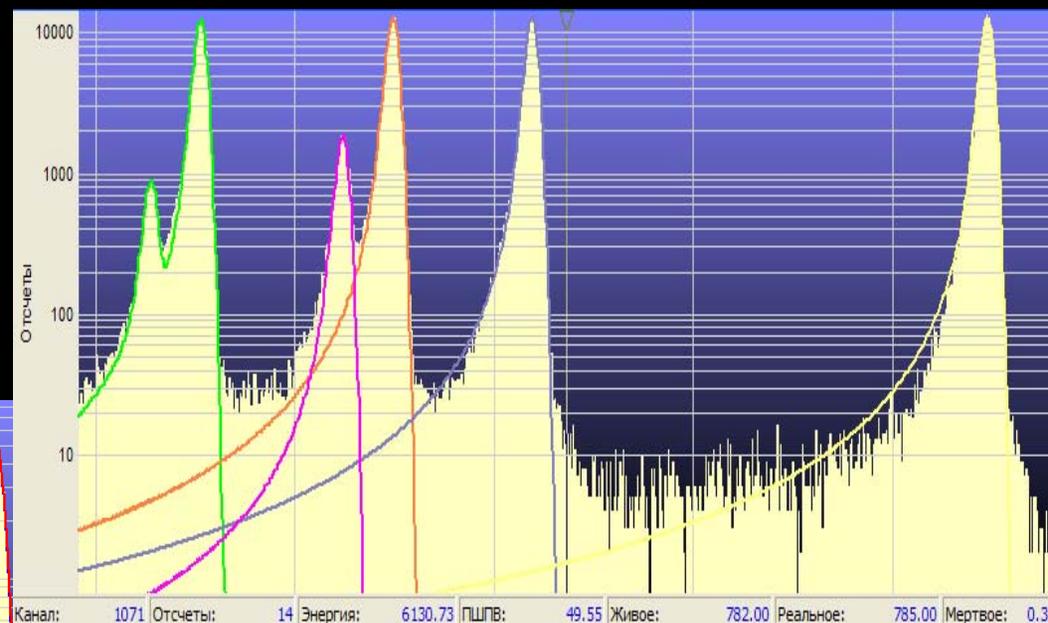
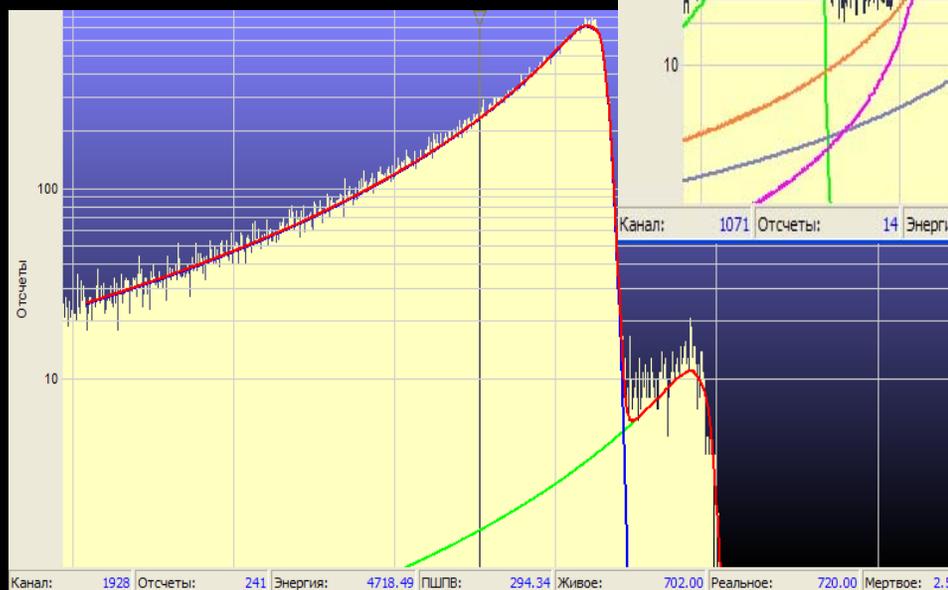


SpectraLineGP - Precision Processing of Gamma Spectra Collected by HPGe-Detectors. Identification and Activity Calculation.

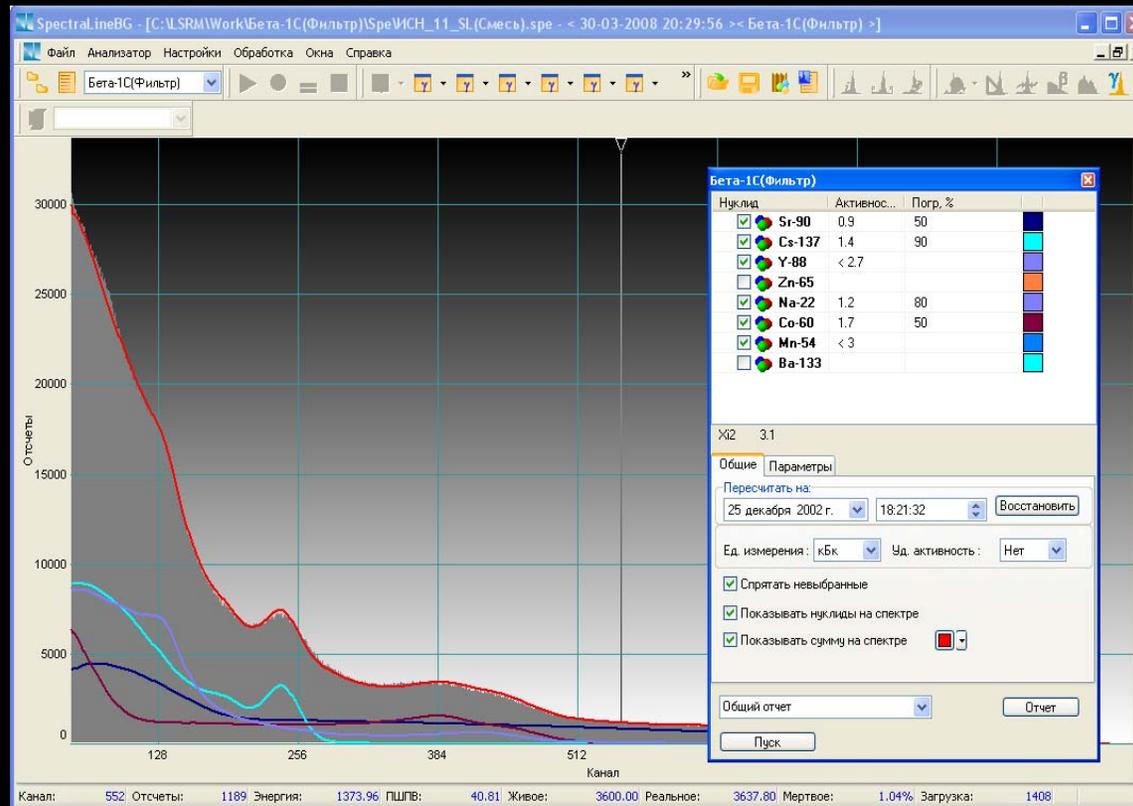


SpectraLineADA- Alpha Spectra Processing.

The curve of a response function provides the operations with both “thin” and “thick” sources of alpha-rays.



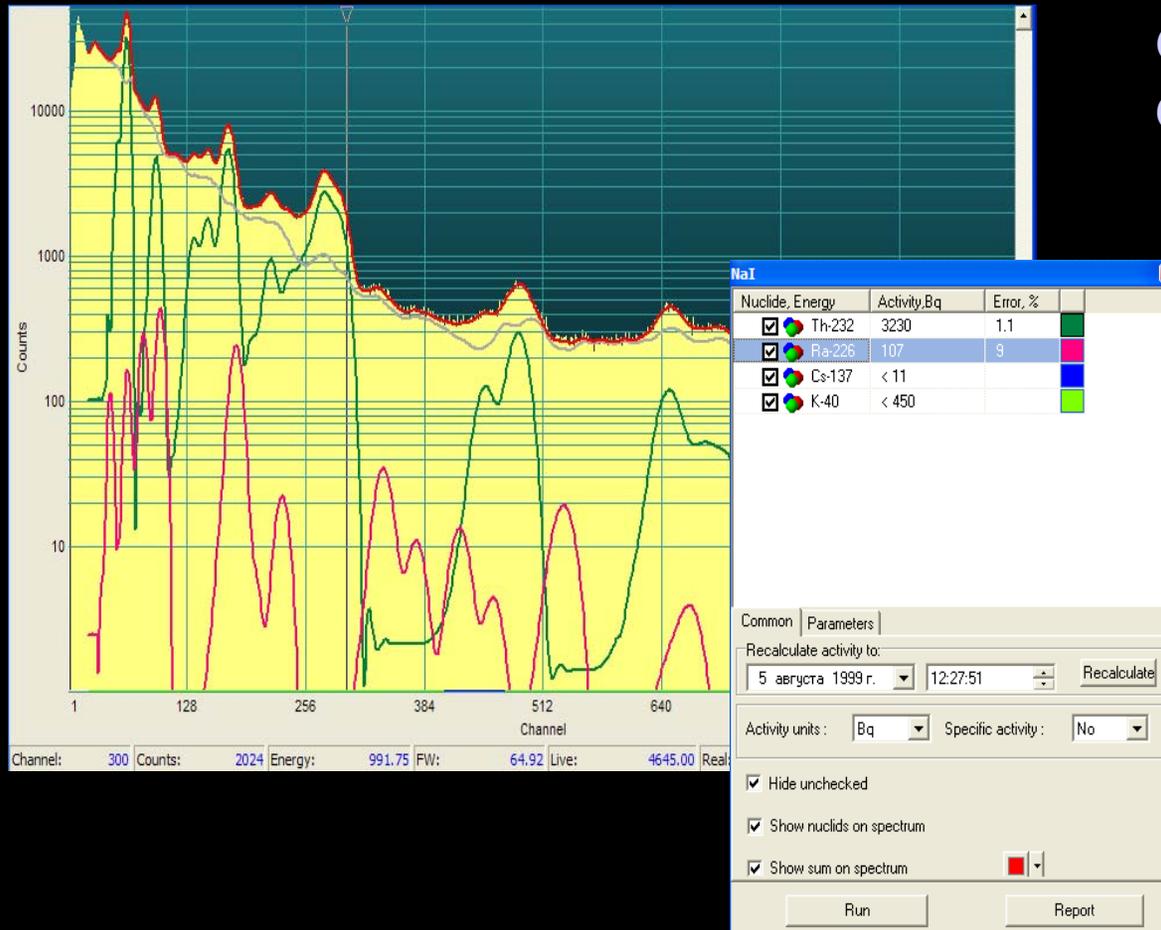
SpectraLineBG - Beta – and Scintillation Gamma Spectrometry



Beta spectrometry

Activity calculation
by reference
spectra method

SpectraLineBG - Beta – and Scintillation Gamma Spectrometry



Gamma spectrometry
Our own method of
activity calculation -

quasi- reference
spectra method

SpectraLineHandy

Spectrometric Analysis with HPGe, NaI, LaBr (Cl), CdTe - Gamma-ray Spectrometers.

- **Identification and activity calculation of the sources in shipping containers**
- **Determination of uranium concentration**
- **Isotope analysis of plutonium samples**

14900 - Development and Test of Field Useable Software for the Analysis of Gamma Spectra of Seized Sources

Field and remote use expert system for reachback support to law enforcement officers performing radiation monitoring at borders or in a country

What is Meant by the Term “Multipurpose”?

- Operations with detectors of different types, with both low and high resolution, and with analyzers of different manufacturers
- Solving of various tasks, which use spectrometric methods of analysis
- Possible adaptation of the software for realization of new measurement methods

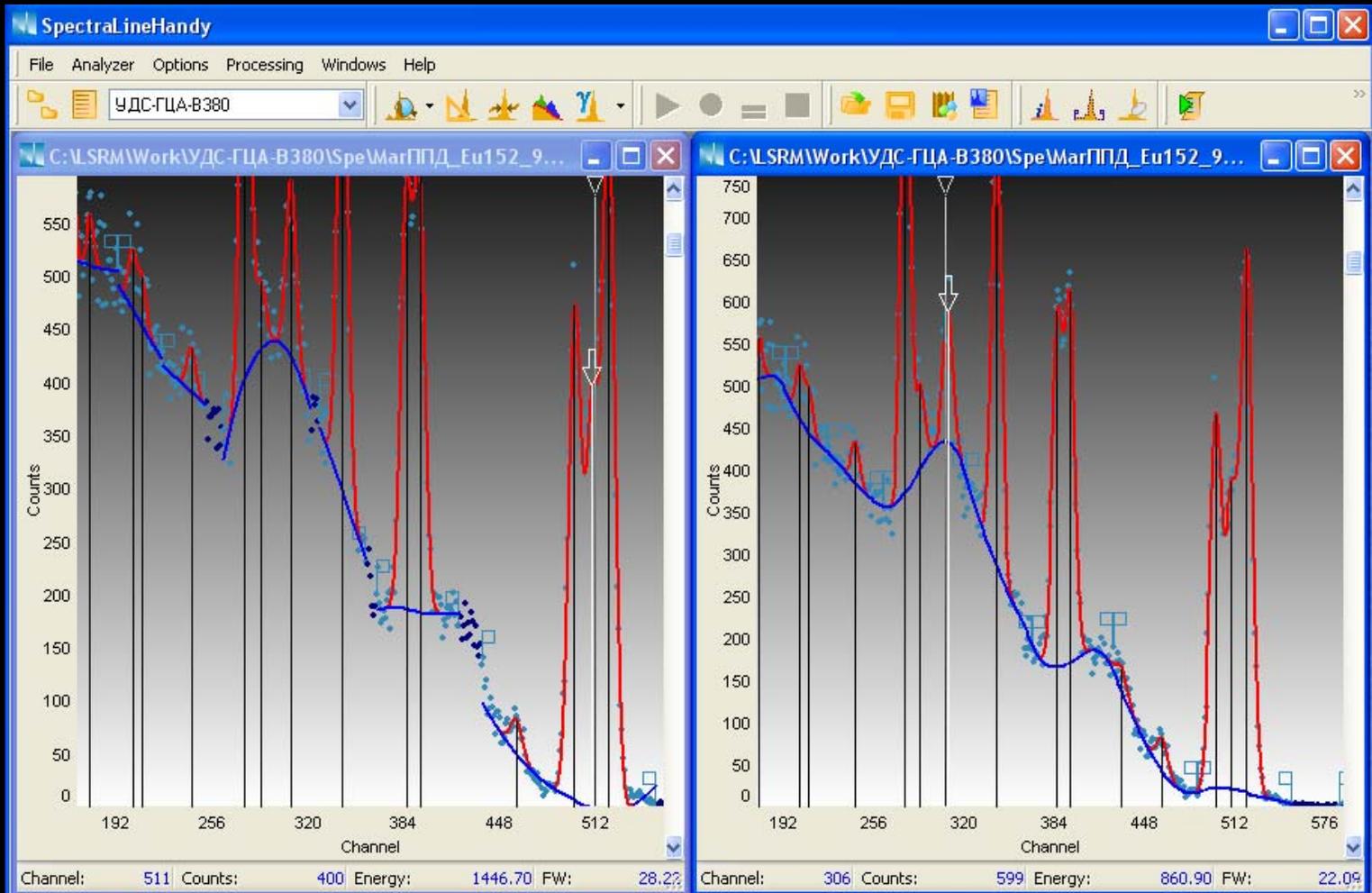
This Multifunctionality is Provided by

- **A wide variety of spectra processing algorithms**
- **Software architecture and flexible interface**
- **Modern updatable nuclear data**

Algorithms

- Calibration procedures, including calibrations by
 - energy
 - resolution
 - peak shape (including X-ray and annihilation peaks)
 - registration efficiency (with break on the bound of absorption)
- Several fitting procedures. The most effective one is done by all spectra lines simultaneously using the intensities ratio of every nuclide and their uncertainties, including
 - Peaks areas uncertainty
 - Registration efficiency uncertainty
 - Uncertainty of the table lines yields
 - Absorption uncertainty in the source material
- When the spectrum intervals are fitted, the influence of peaks in neighbor intervals and the influence of background continuity on the intervals boundaries (if they don't intersect) are taking into consideration. This way helps one to describe the background by a polynomial with low degree.
- Several procedures of identification and activity calculation

Algorithms - «sewing» of spectrum interval



Software Architecture and Interface

- **Modular approach – the dynamically linked DLL – modules**
 - **Conjunction with hardware**
 - **Methods of activity calculation**
 - **Realization of measurement methods**
 - **Connection to databases**
- **Parameters configuration**
- **Processing scenarios**
 - **Calibration commands**
 - **Loading of the informative zones**
 - **Parameters calculation – peaks search, fitting, activity etc.**
 - **Requirements analysis**

Nuclear Data

- Radioactive decay information on the basis of ENSDF-file
- Data on photons cross section based on XCOM.

SpectraLineHandy adaptation for determination of isotopic composition of uranium and plutonium samples

- **Calibration by energy and resolution**
- **Peak shape calibration – consideration of X-ray peaks shape**
- **Calibration by relative registration efficiency (by the measured sample)**
- **Approximation of spectrum informative intervals**
- **Calculation of relative activities and mass fractions of isotopes**

Uranium-Planar.Isc

- clear
- search(3)
- \$idwin=1
- encalibr(1,0, U-Calibr0.lib , U.cen,1)
- reset(idwin)
- clear
- xraypatterns([89.957 94.000 92.282 90.00 93.357 87.000 94.654
100.000 95.863 90.000 98.434 110.000])
- loadzones(U-Calibr.zon)
- encalibr(2,0, U-Calibr.lib , \U.cen,1)
- clear
- loadzones(C:\Lsrm\Work\U-HPGe-Planar\Data\U-Eff.zon)
- recalibrate(0.001,[94.654 98.434 143.760 185.715 205.31])
- clear
- loadzones(Planar.zon)
- activity(AllZonesSew)
- showwindow(activityinfo)

Source Code Verification

International Workshop on Gamma Evaluation Codes for Plutonium and Uranium Isotope Abundance Measurements by High-Resolution Gamma Spectrometry: Current Status and Future Challenges

*Institute for Transuranium Elements, Karlsruhe
November 14 – 16, 2005*

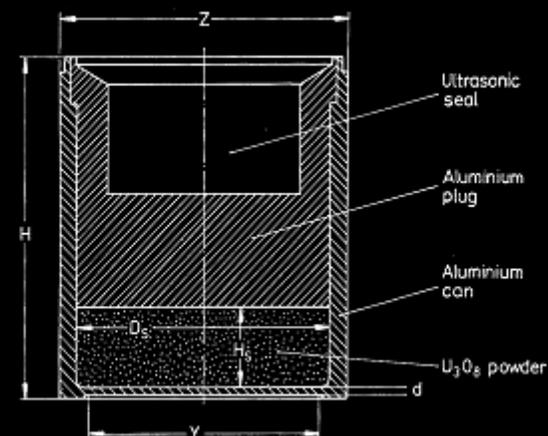
STUDY OF THE MGAU APPLICABILITY TO ACCURATE ISOTOPIC CHARACTERIZATION OF URANIUM SAMPLES

Andrey Berlizov and Volodymyr Tryshyn

Institute for Nuclear Research
National Academy of Sciences of Ukraine

Standard Reference Material SRM 969

Material: U_3O_8 powder, $m = 200$ g, $\rho = 2.5$ g/cm³;
 Externals: $Z = 80$ mm, $H = 90$ mm;
 Sample volume: $D_S = 70$ mm, $H_S = 20.8$ mm;
 Al window thickness: $d = 2$ mm.



Isotope	Reference sample, mass %				
	031	071	194	295	446
²³⁴ U	0.0020(2)	0.0052(2)	0.0171(2)	0.0279(4)	0.0359(3)
²³⁵ U	0.3166(2)	0.7119(5)	1.9420(14)	2.9492(21)	4.4623(32)
²³⁶ U	0.0146(3)	<0.00002	0.0003(1)	0.0033(2)	0.0068(2)
²³⁸ U	99.6668(4)	99.2828(4)	98.0406(18)	97.0196(29)	95.4950(32)



Certified Reference Material CRM 146

Material: U₃O₈ powder, m = 230 g, ρ = 3.78 g/cm³;
 Externals: Z = 80 mm, H = 90 mm;
 Sample volume: D_S = 70 mm, H_S = 15.8 mm;
 Al window thickness: d = 2 mm.



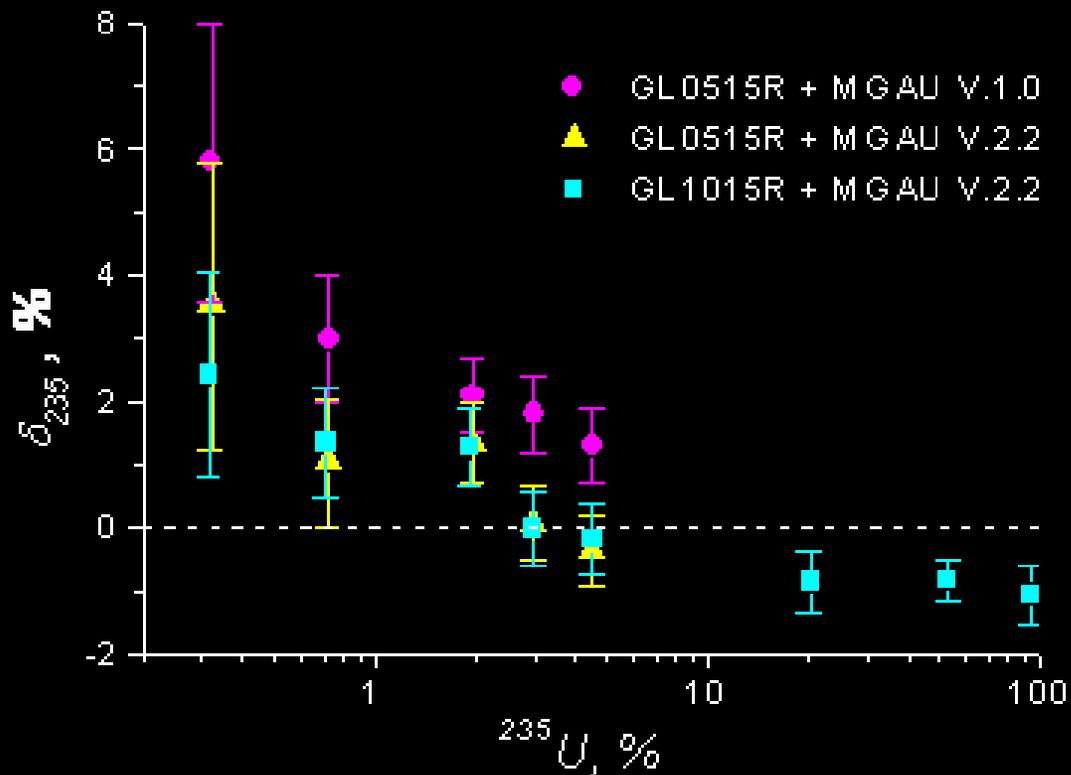
Isotope	Reference sample, mass %		
	20	52	93
²³⁴ U	0.1486 (2)	0.3718(5)	0.9800(15)
²³⁵ U	20.107 (10)	52.488(21)	93.1703(3)
²³⁶ U	0.1973(6)	0.2645(3)	0.2937(12)
²³⁸ U	79.547(10)	46.876(21)	5.5559(26)

Hardware

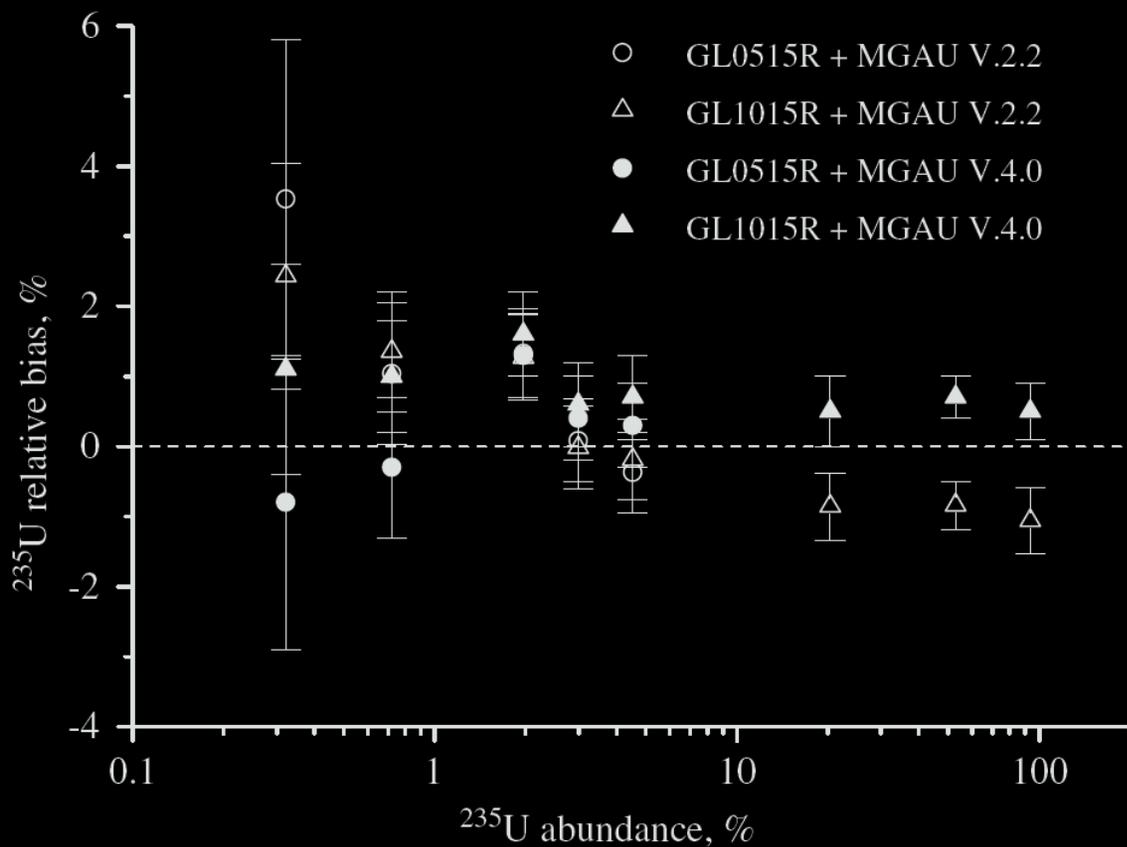
- Detector - LEGe GL0515R, S=500 mm² d=15 mm, input window – 0.5 mm Al.
- InSpector Portable Spectroscopy Workstation, Model 1200UPU.
- MGAU V.1.0 V2.2 uranium isotopic software.



Certified Reference Material CRM 146 & SRM 969

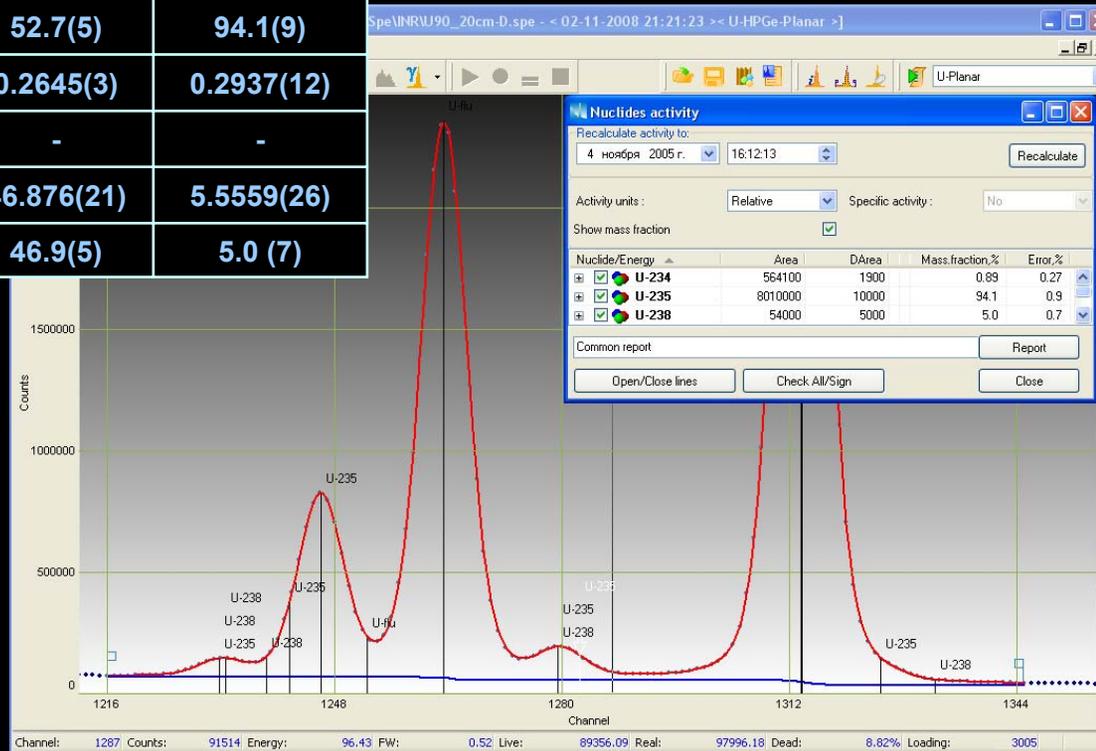


Certified Reference Material CRM 146 & SRM 969



Certified Reference Material CRM 146

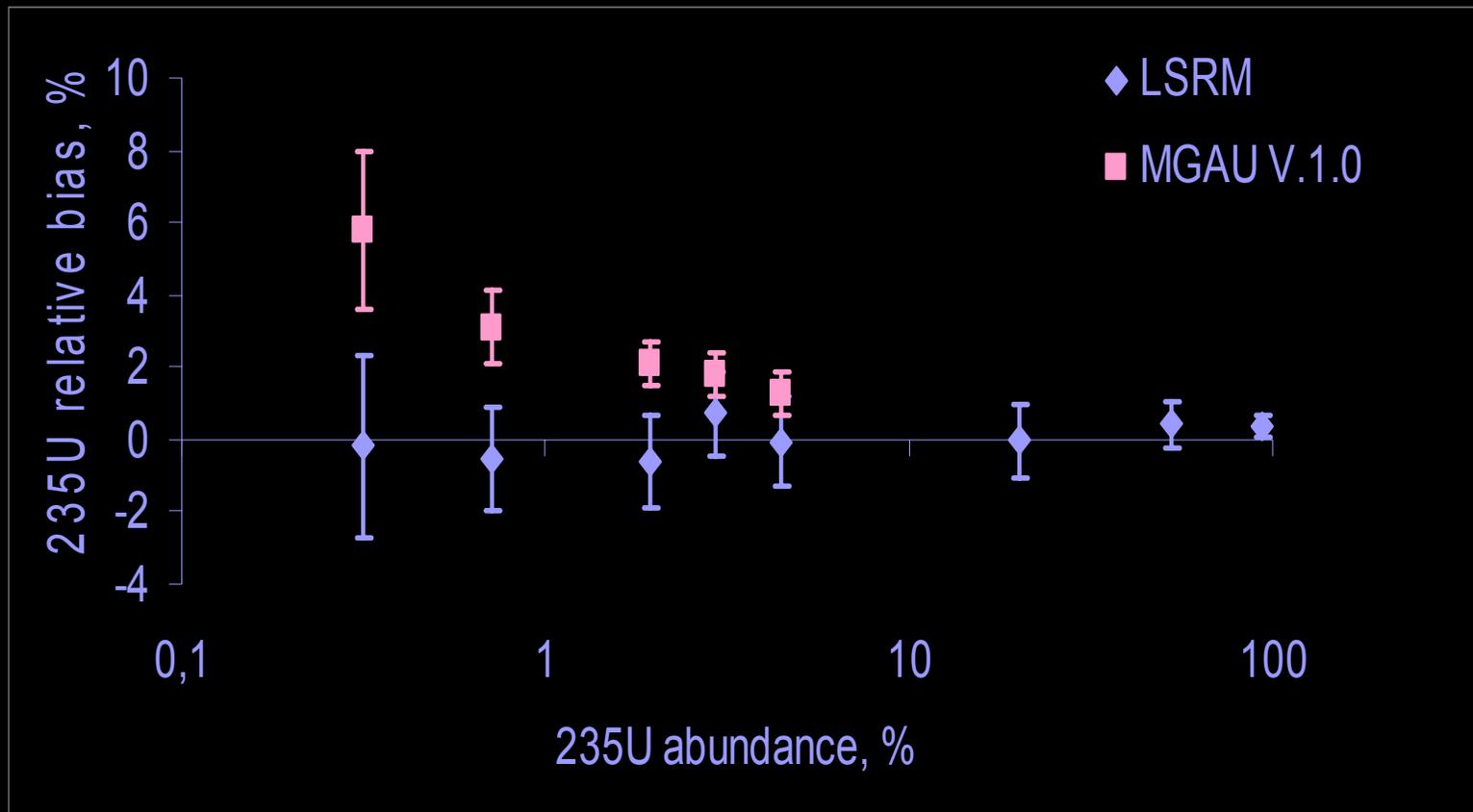
Isotope		Reference sample, mass %		
		20	52	93
²³⁴ U	Reference	0.1486 (2)	0.3718(5)	0.9800(15)
	Lsrm	0.138(21)	0.35(5)	0.89 (27)
²³⁵ U	Reference	20.107 (10)	52.488(21)	93.1703(3)
	Lsrm	20.18 (22)	52.7(5)	94.1(9)
²³⁶ U	Reference	0.1973(6)	0.2645(3)	0.2937(12)
	Lsrm	-	-	-
²³⁸ U	Reference	79.547(10)	46.876(21)	5.5559(26)
	Lsrm	79.68(22)	46.9(5)	5.0 (7)



Standard Reference Material SRM 969

Isotope		Reference sample, mass %				
		031	071	194	295	446
²³⁴ U	Reference	0.0020(2)	0.0052(2)	0.0171(2)	0.0279(4)	0.0359(3)
	Lsrn	0.0016(4)	0.0049(8)	0.0160(24)	0.026(4)	0.033(5)
²³⁵ U	Reference	0.3166(2)	0.7119(5)	1.9420(14)	2.9492(21)	4.4623(32)
	Lsrn	0.308(9)	0.702(14)	1.941(29)	2.95(4)	4.49(6)
²³⁶ U	Reference	0.0146(3)	<0.00002	0.0003(1)	0.0033(2)	0.0068(2)
	Lsrn	-	-	-	-	-
²³⁸ U	Reference	99.6668(4)	99.2828(4)	98.0406(18)	97.0196(29)	95.4950(32)
	Lsrn	99.690(9)	99.293(14)	98.043(29)	97.03(4)	95.48(6)

Certified Reference Material CRM 146 & SRM 969



U reference spectra from LNHB and LLNL

<http://www.nucleide.org/spectres.htm>

Laboratoire National Henri Becquerel Uranium spectra						
LLNL spectra <small>(all files ASCII format)</small>	LNHB spectra					
	Coaxial detector <small>(all files ASCII format) (all files CHN format)</small>		CZT detector <small>(all files ASCII format) (all files CHN format)</small>		Planar detector <small>(all files ASCII format) (all files CHN format)</small>	
125v003.asc	G-125VC ASC	G-125vc.chn	C-125.asc	C-125.chn	X-125VC ASC	X-125vc.chn
15411001.asc	G-125VD ASC	G-125vd.chn	C-1541 ASC	C-1541.chn	X-125VD ASC	X-125vd.chn
15411002.asc	G-125VE ASC	G-125ve.chn	C-1542 ASC	C-1542.chn	X-125VE ASC	X-125ve.chn
15411003.asc	G-1541C ASC	G-1541c.chn	C-1613 ASC	C-1613.chn	X-1541C ASC	X-1541c.chn
15411004.asc	G-1541D ASC	G-1541d.chn	C-1614 ASC	C-1614.chn	X-1541D ASC	X-1541d.chn
1542-001.asc	G-1541E ASC	G-1541e.chn	C-R1 ASC	C-r1.chn	X-1541E ASC	X-1541e.chn
1542-002.asc	G-1542C ASC	G-1542c.chn	C-R2 ASC	C-r2.chn	X-1542C ASC	X-1542c.chn
1542-003.asc	G-1542D ASC	G-1542d.chn	C-R3 ASC	C-r3.chn	X-1542D ASC	X-1542d.chn
1542-004.asc	G-1542E ASC	G-1542e.chn	C-R4 ASC	C-r4.chn	X-1542E ASC	X-1542e.chn
1542-005.asc	G-1613C ASC	G-1613c.chn	C-R5 ASC	C-r5.chn	X-1613C ASC	X-1613c.chn
1542-006.asc	G-1613D ASC	G-1613d.chn	C-X2 ASC	C-x2.chn	X-1613D ASC	X-1613d.chn
1542-007.asc	G-1613E ASC	G-1613e.chn	C-Y2 ASC	C-y2.chn	X-1613E ASC	X-1613e.chn
1542-008.asc	G-1614C ASC	G-1614c.chn			X-1614C ASC	X-1614c.chn
1542-009.asc	G-1614D ASC	G-1614d.chn			X-1614D ASC	X-1614d.chn
1542-010.asc	G-1614E ASC	G-1614e.chn			X-1614E ASC	X-1614e.chn
16131001.asc	G-R1C ASC	G-r1c.chn			X-R1C ASC	X-r1c.chn
16131002.asc	G-R2C ASC	G-r2c.chn			X-R2C ASC	X-r2c.chn
16131003.asc	G-R3C ASC	G-r3c.chn			X-R3C ASC	X-r3c.chn
16141001.asc	G-R4C ASC	G-r4c.chn			X-R4C ASC	X-r4c.chn
16141002.asc	G-R5C ASC	G-r5c.chn			X-R5C ASC	X-r5c.chn
16141003.asc	G-X2C ASC	G-x2c.chn			X-X3C ASC	X-x3c.chn
U0_017 ASC	G-X2CC ASC	G-x2cc.chn			X-X3CC ASC	X-x3cc.chn
U0_483 ASC	G-X2D ASC	G-x2d.chn			X-X3D ASC	X-x3d.chn
U0_991 ASC	G-X2DD ASC	G-x2dd.chn			X-X3DD ASC	X-x3dd.chn
U10_075 ASC	G-X2E ASC	G-x2e.chn			X-X3E ASC	X-x3e.chn
U2_013.asc	G-X2EE ASC	G-x2ee.chn			X-X3EE ASC	X-x3ee.chn
U3_009 ASC	G-Y2C ASC	G-y2c.chn			X-Y2C ASC	X-y2c.chn
U49_38 ASC	G-Y2CC ASC	G-y2cc.chn			X-Y2CC ASC	X-y2cc.chn
U4_949 ASC	G-Y2D ASC	G-y2d.chn			X-Y2D ASC	X-y2d.chn
U75_13 ASC	G-Y2DD ASC	G-y2dd.chn			X-Y2DD ASC	X-y2dd.chn
U93_076 ASC	G-Y2E ASC	G-y2e.chn			X-Y2E ASC	X-y2e.chn
q295001.asc	G-Y2EE ASC	G-y2ee.chn			X-Y2EE ASC	X-y2ee.chn
q295002.asc						
q295003.asc						

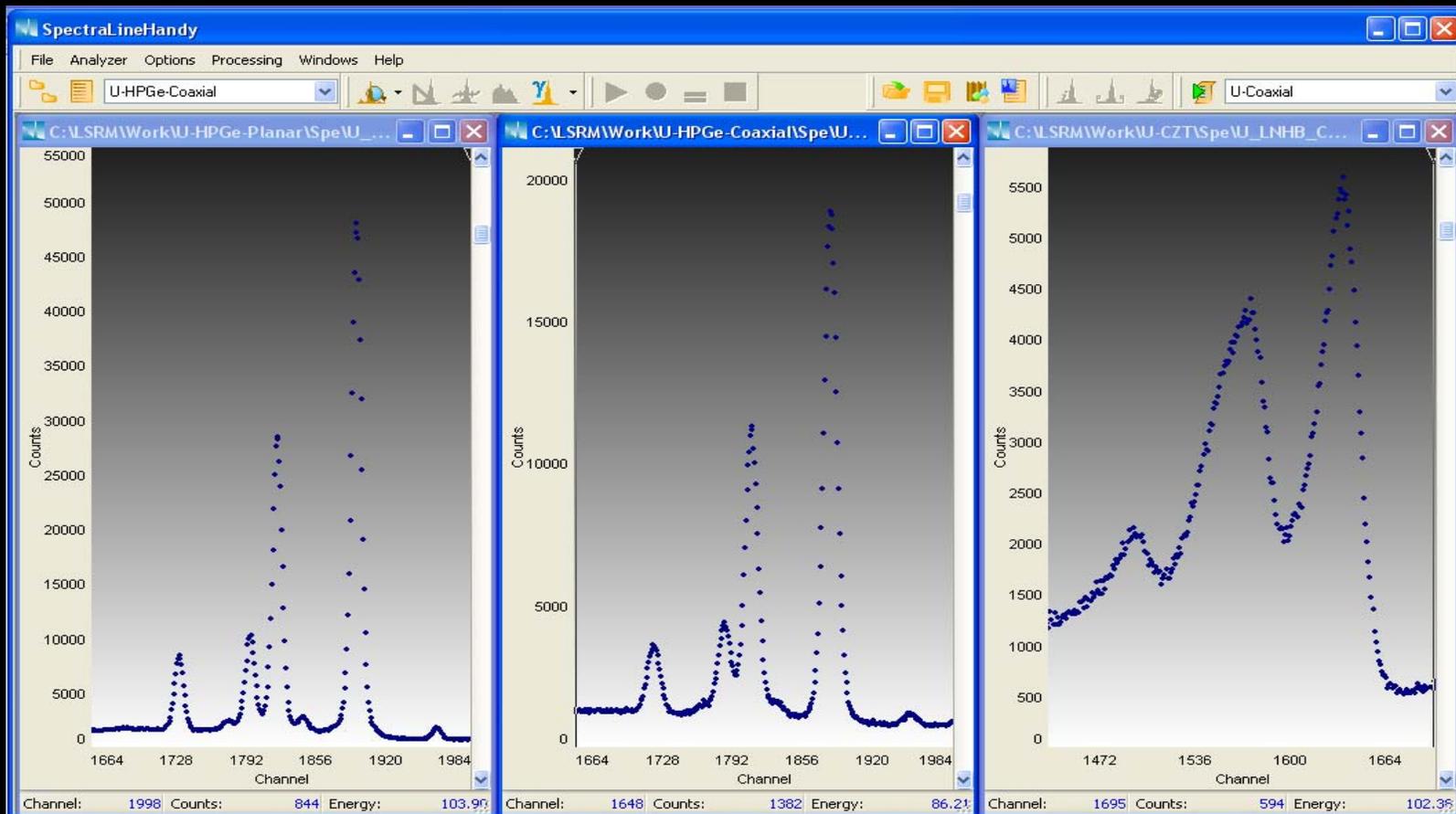
U reference spectra from LNHB and LLNL

<http://www.nucleide.org/spectres.htm>

HPGe-Planar
FWHM at 122 keV: 0.52 keV

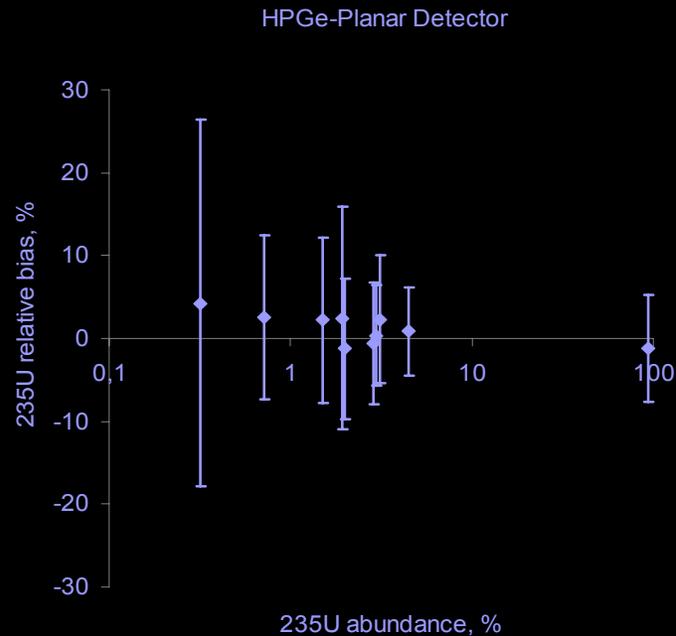
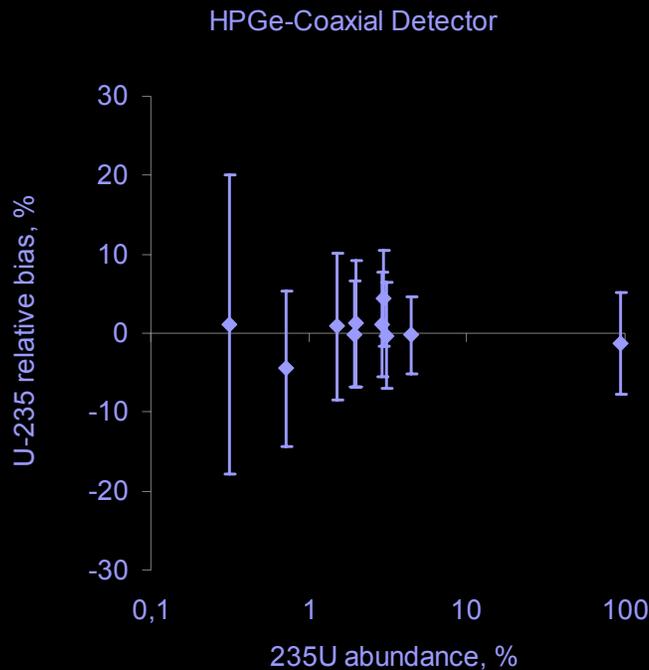
HPGe-Coaxial
0.71 keV

CZT
1.95 keV

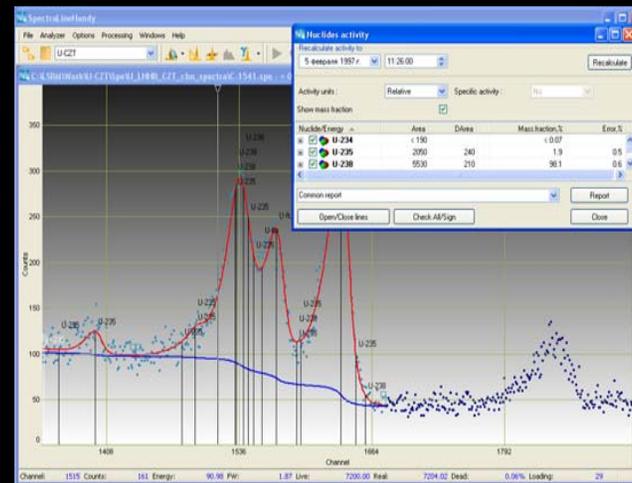
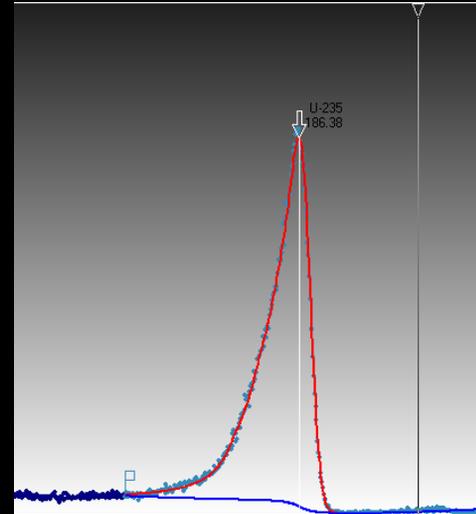
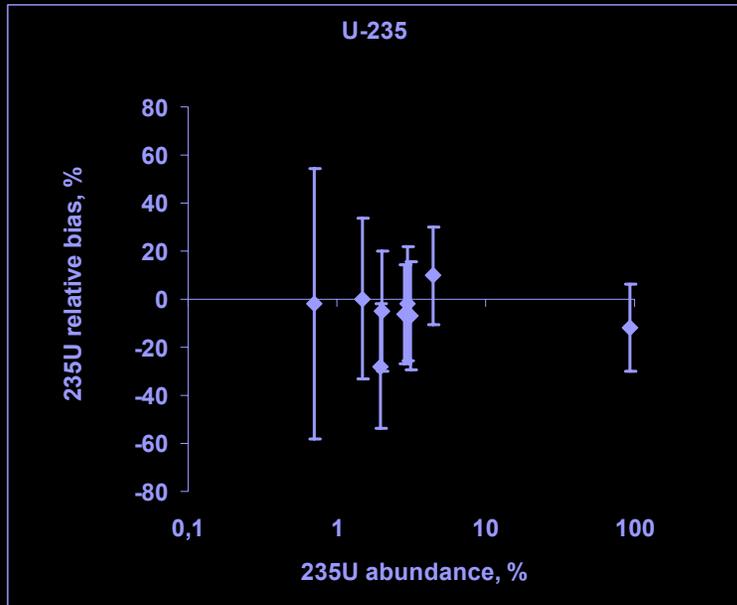


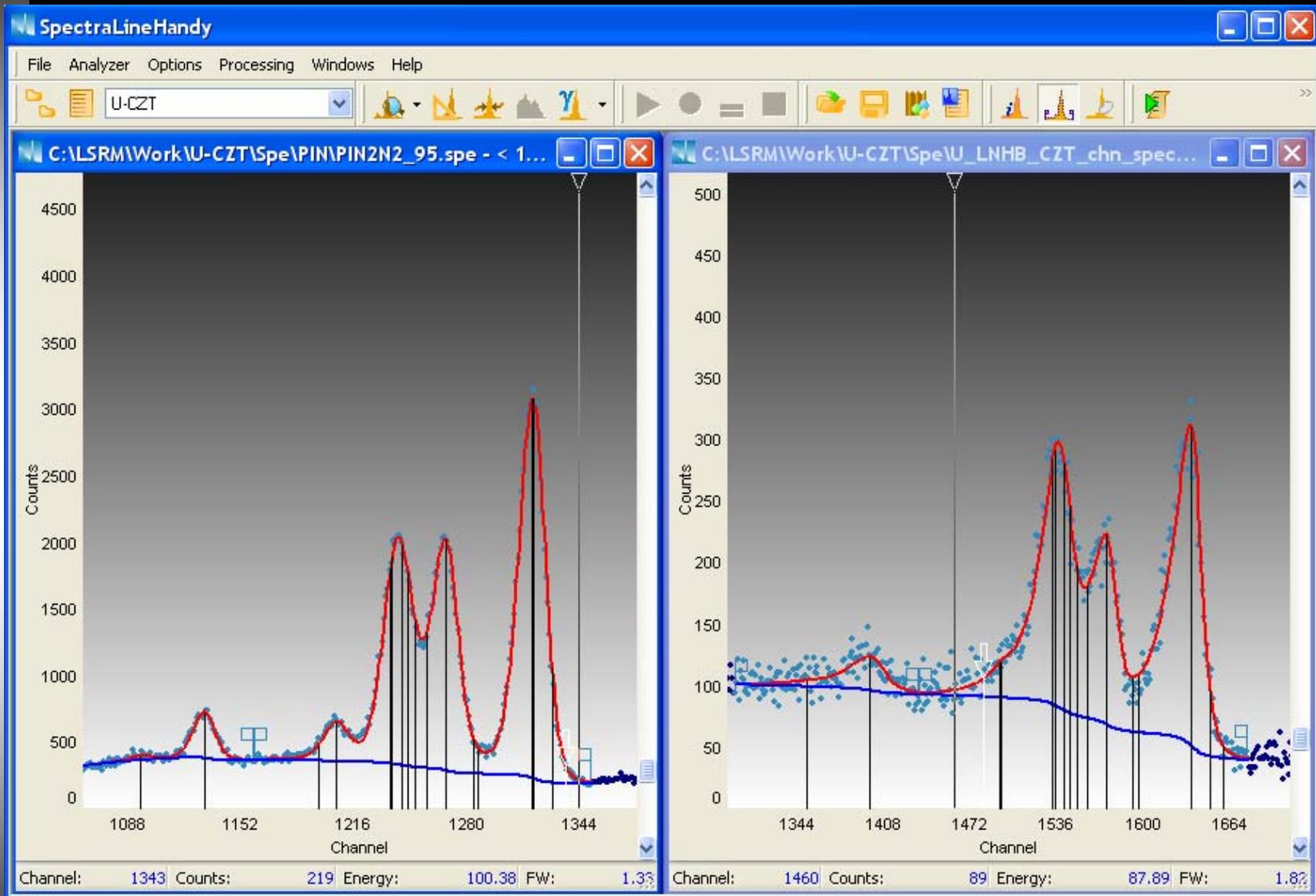
U reference spectra from LNHB and LLNL

<http://www.nucleide.org/spectres.htm>



U reference spectra from LNHB CZT-detector





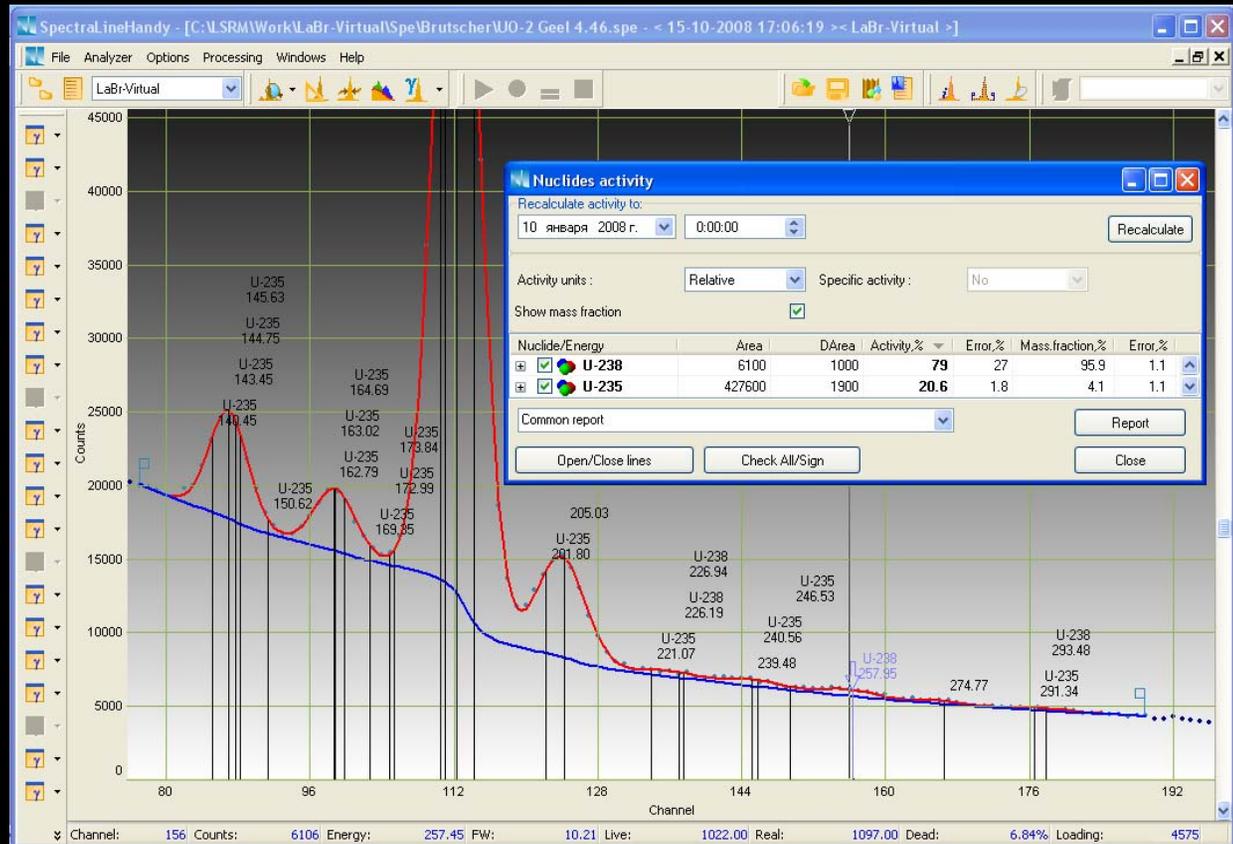
LaBr3 -2x2"

122 кэВ FWHM: 6.1%
661 кэВ FWHM: 2.7%

^{235}U

Passport - 4.46%

Measurement - 4.1+/-1.1 %

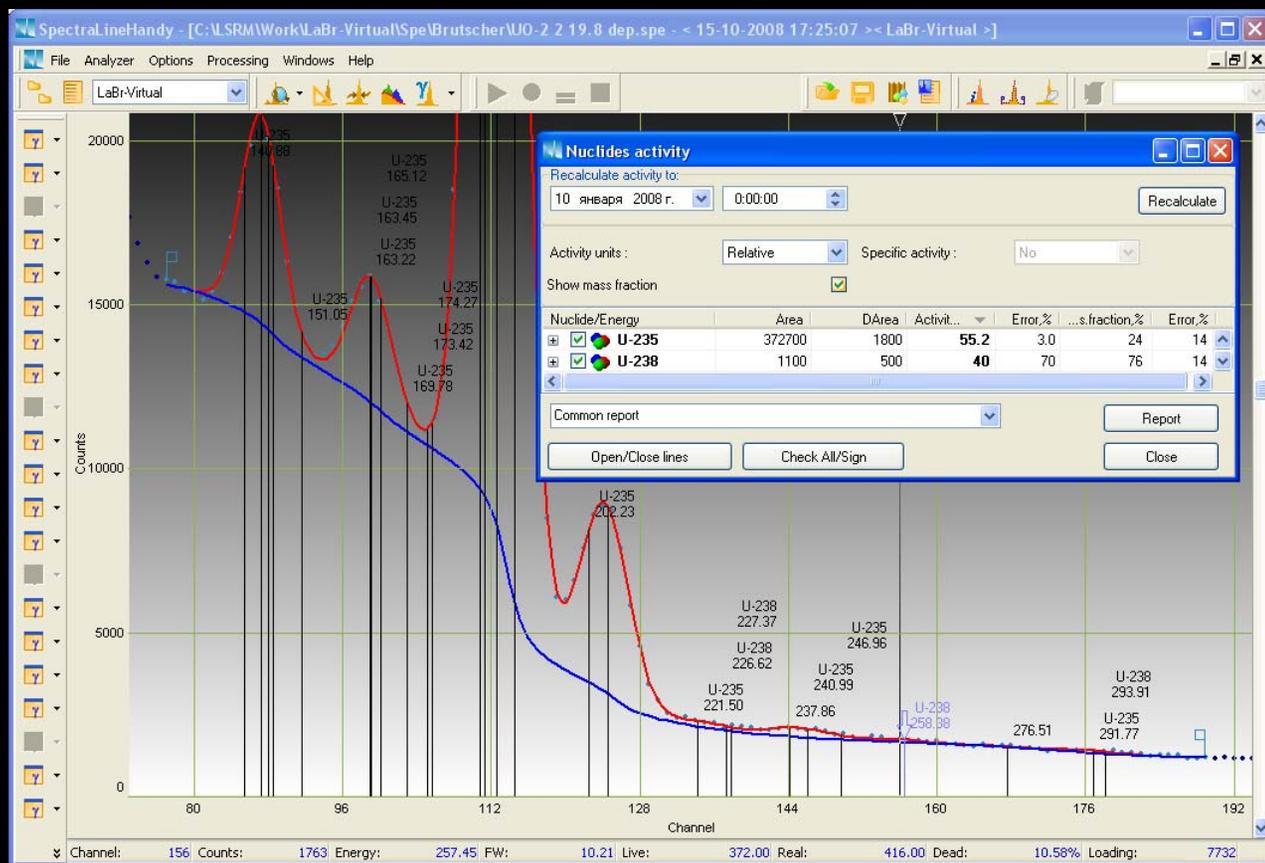


LaBr3 -2x2"

^{235}U

Passport - 19.8%

Measurement 24 \pm 14 %

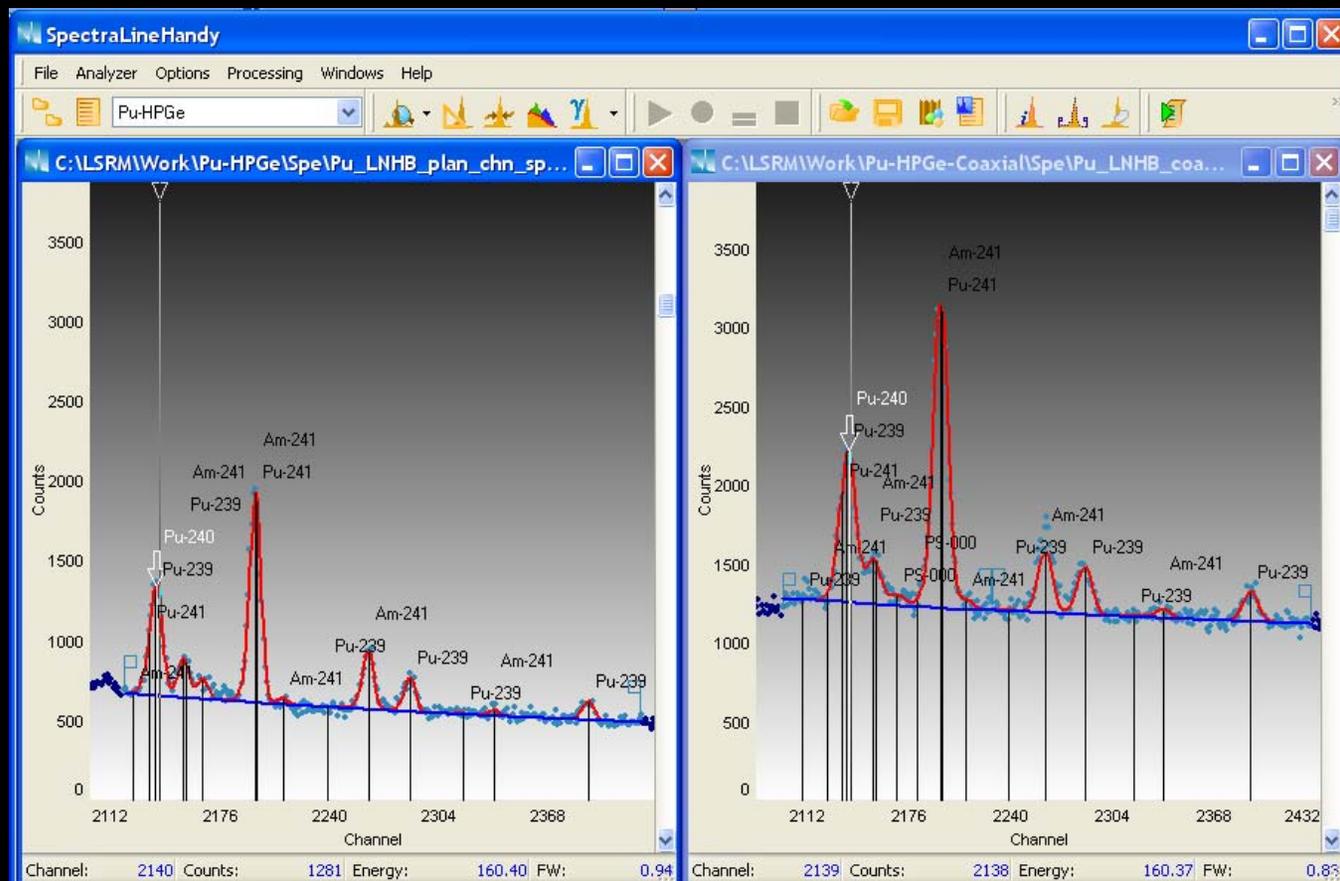


Pu reference spectra from LNHB

<http://www.nucleide.org/spectres.htm>

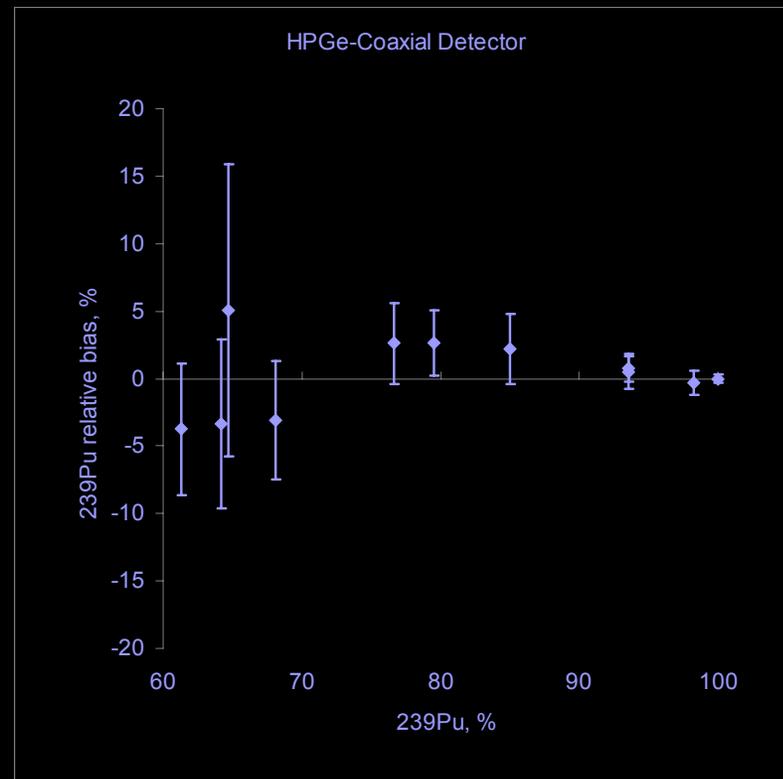
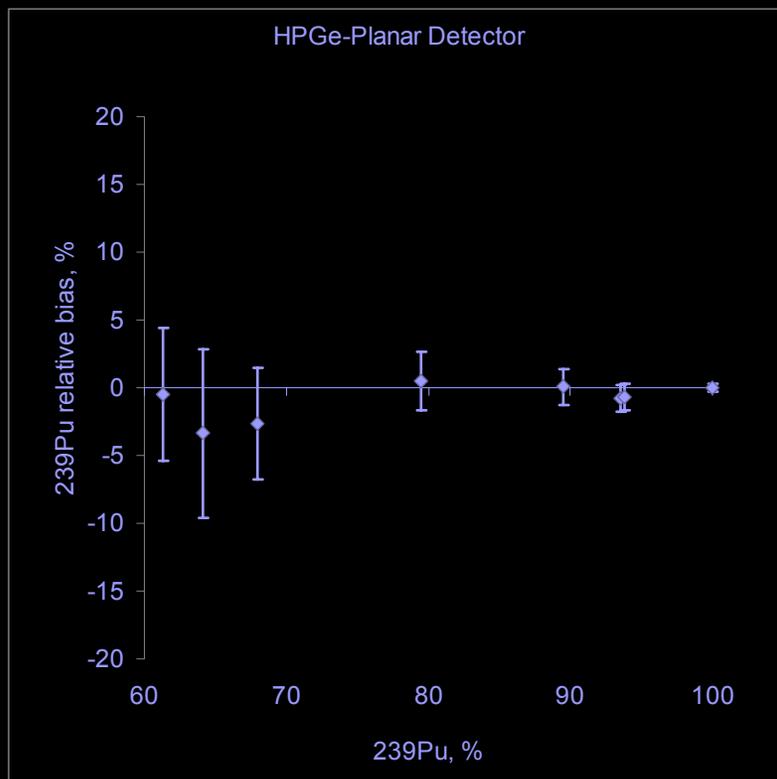
HPGe-Planar
FWHM at 122 keV: 0.52 keV

HPGe-Coaxial
0.71 keV



Pu reference spectra from LNHB

<http://www.nucleide.org/spectres.htm>

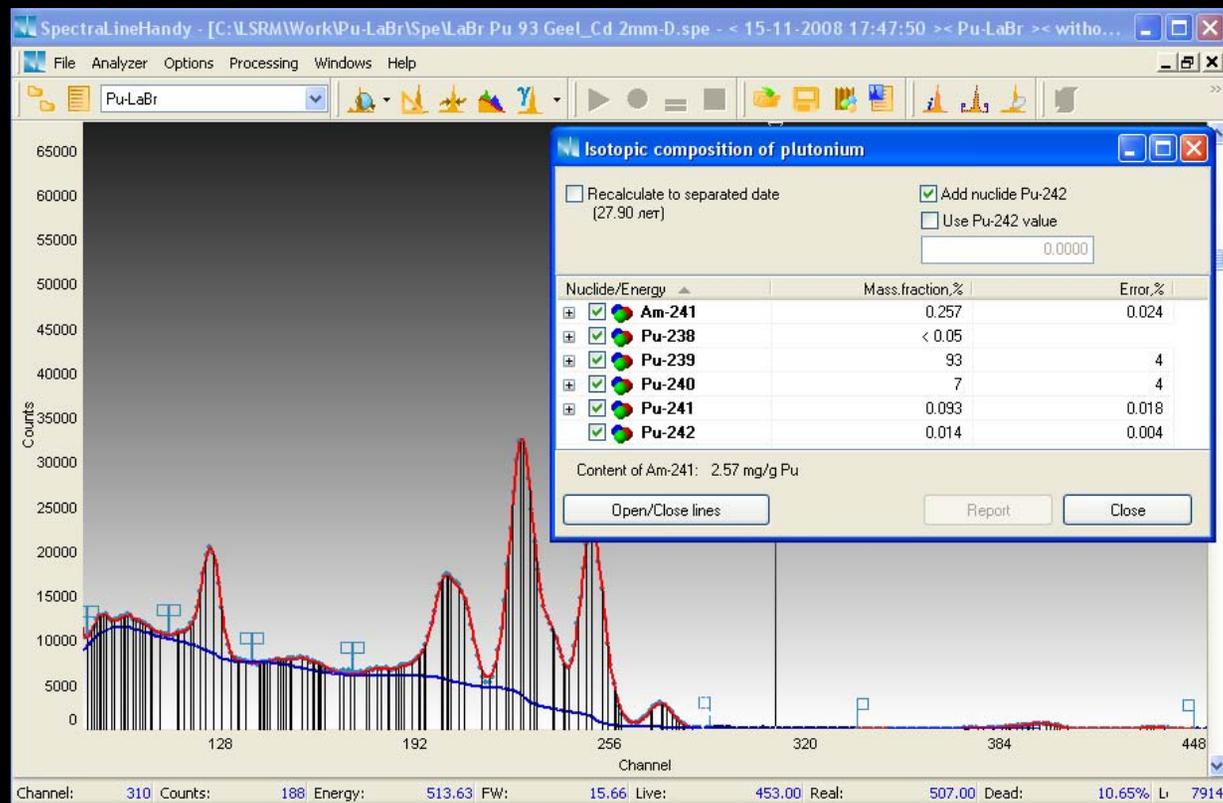


LaBr3 -2x2”

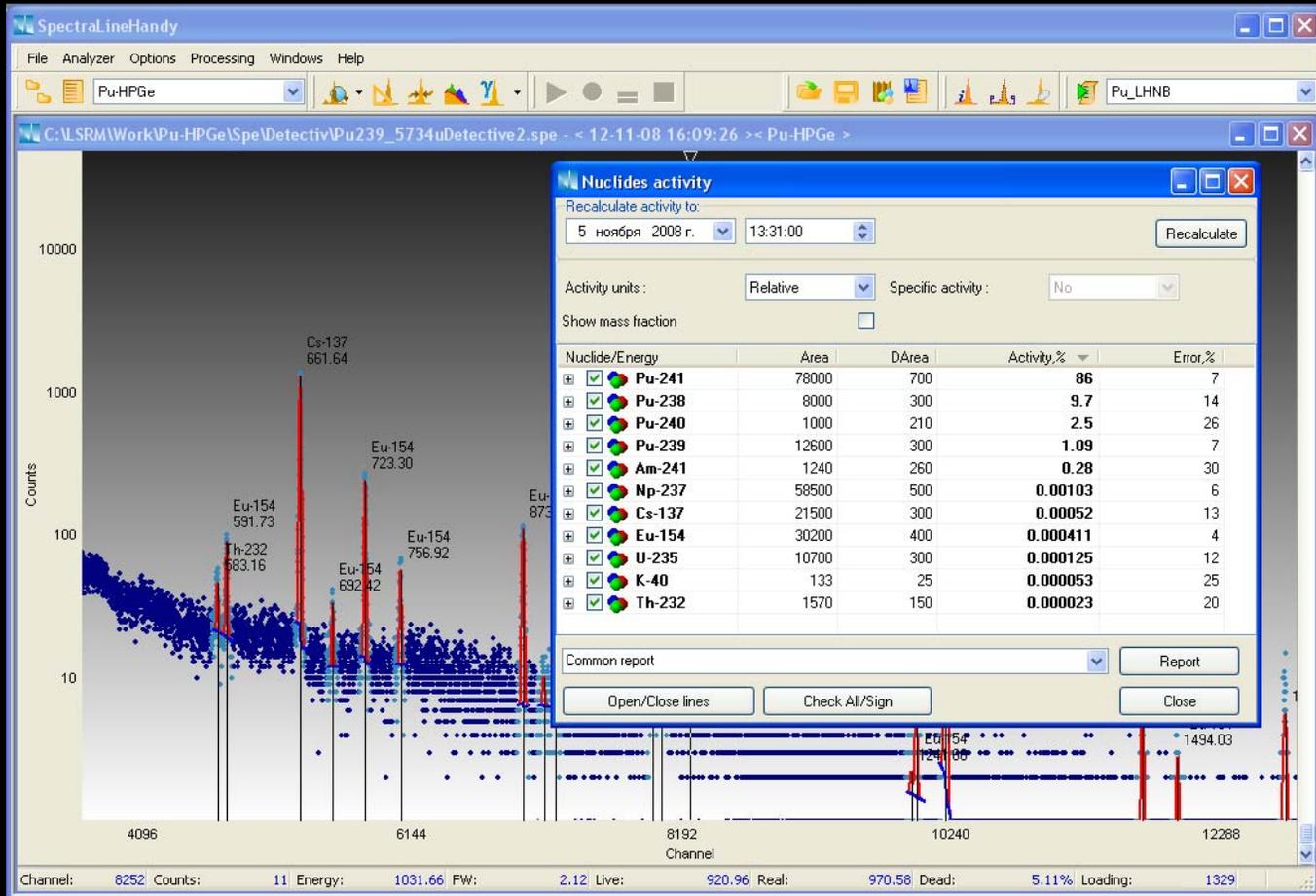
 ^{239}Pu

Passport - 93%

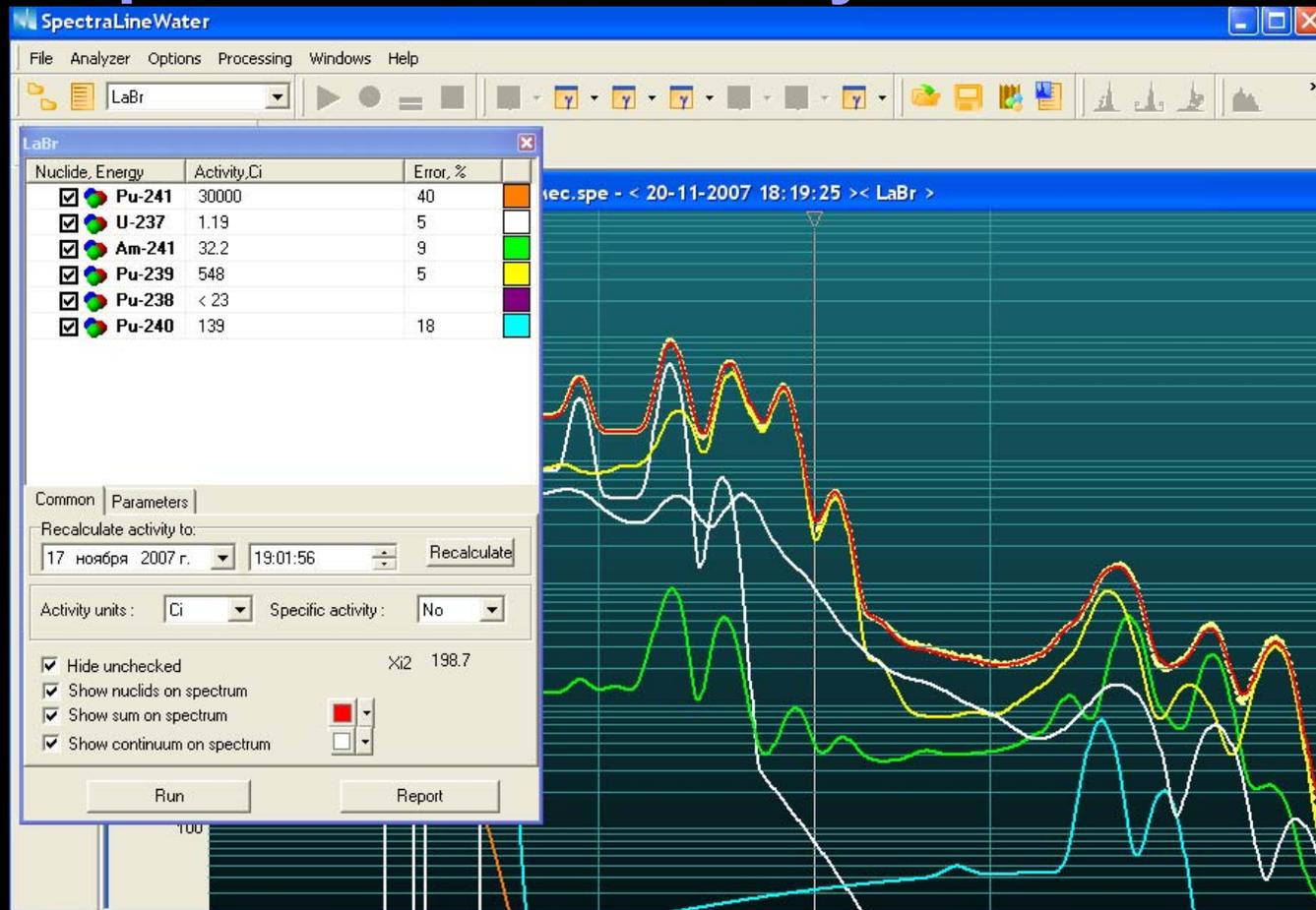
Measurement 93+/-4 %



MicroDetective: FWHM at 122keV = 1.5 keV



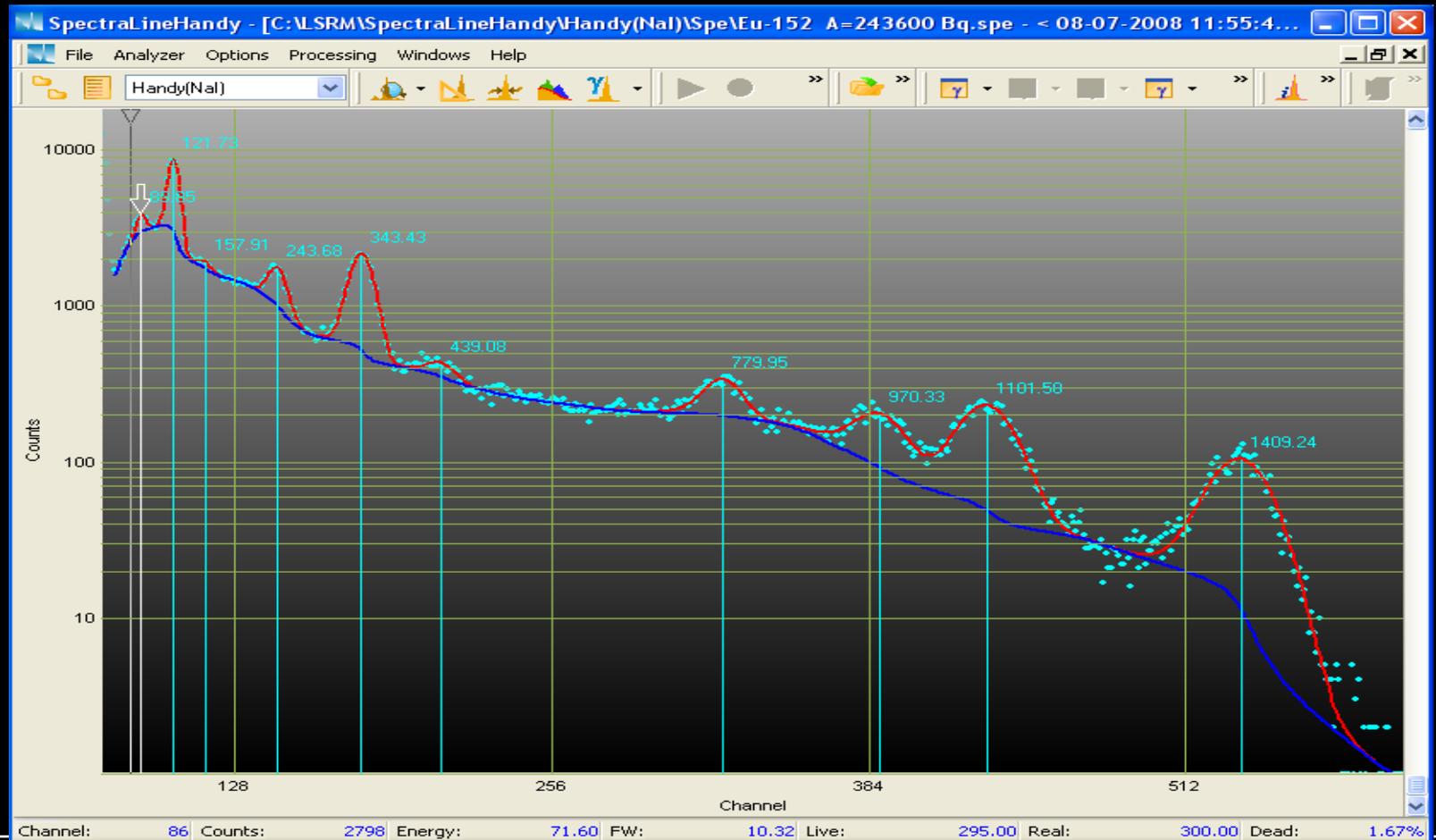
SpectraLineHandy - Plutonium Isotopic Composition Measured by LaBr-3 Detector.



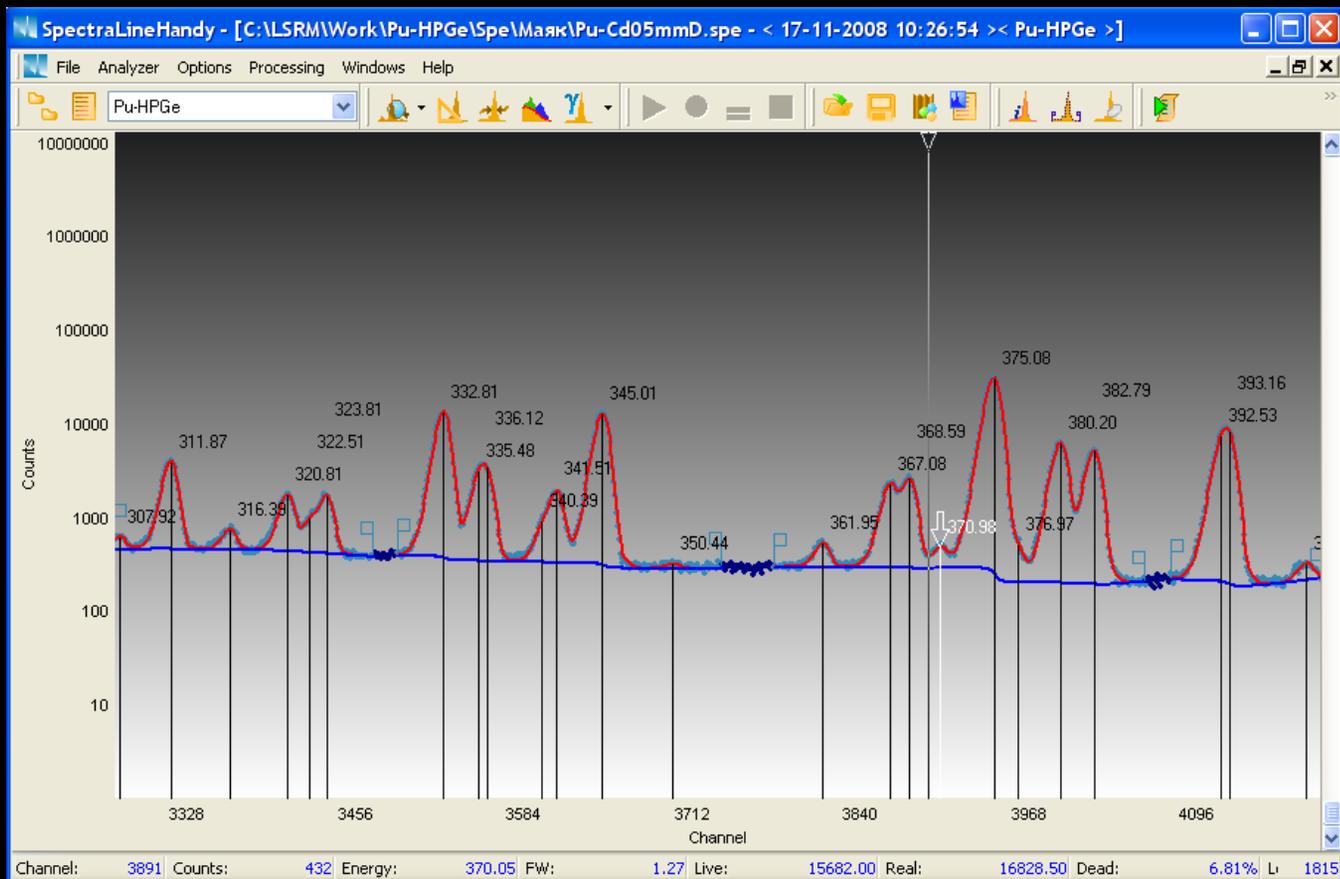
Identification Steps

- The peaks search in the spectrum and the fitting of the spectrum intervals
- Comparison of energy values of the found peaks with the peaks of radionuclides in the user nuclides library, which are the most important for spectrum description, and preparation of the table of nuclides, which can be in the measured sample
- Marking the peaks of all possible nuclides, which are important for spectrum description.
- Re-marking of the spectrum intervals and new fitting of spectrum. Calculation of activity of all nuclides and analysis of their importance for the description of this spectrum.

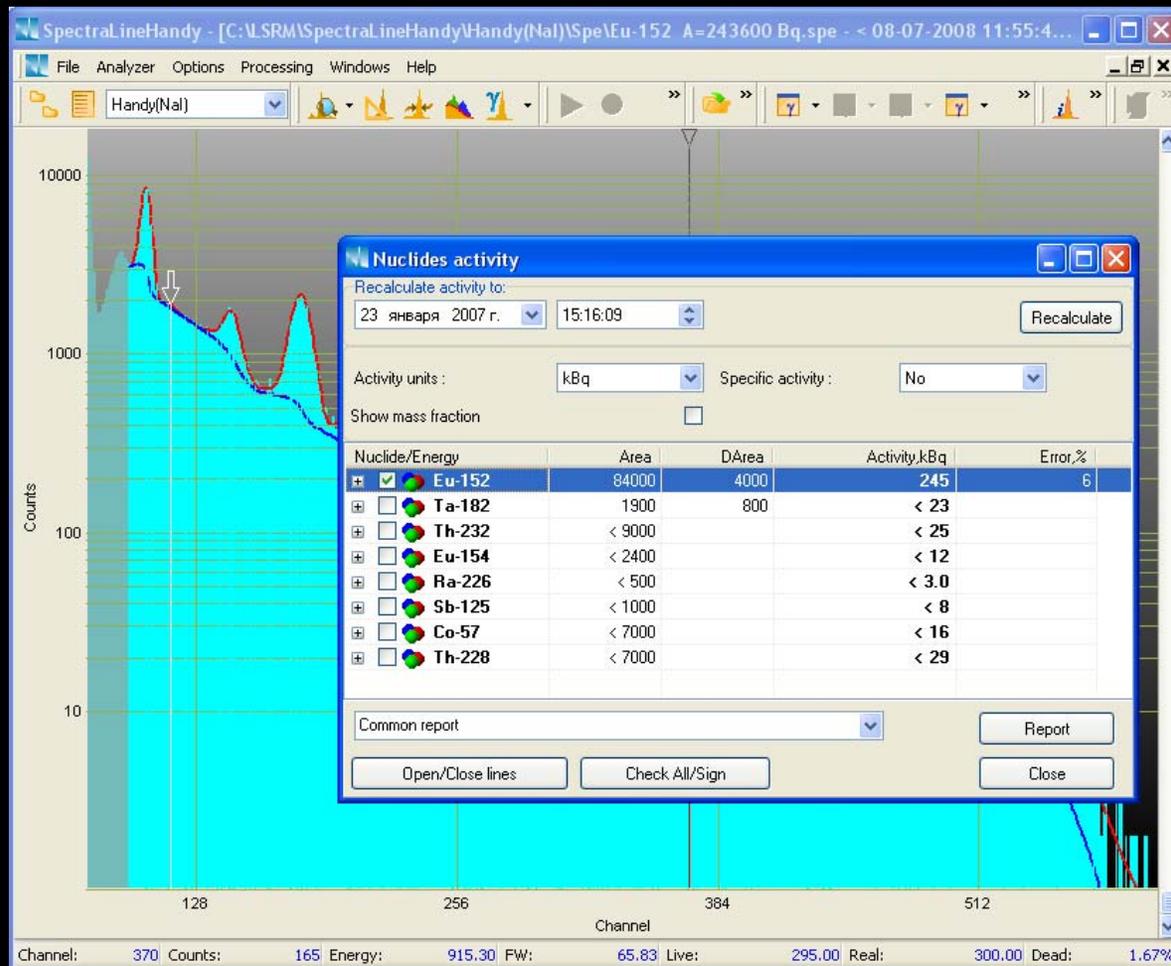
Peaks Search



Peaks Search Procedure – Multiplets Separation



Estimation of Activity of all Probable Nuclides



The Requirements for Successful Identification

- Data for all assumed nuclides from the sample should be in the nuclides library
- Correct energy calibration
- Agreement between parameters of the shipping container, used for calculation, and real values

Extension of Nuclides Library

- By the list of identified nuclides
- By a selected nuclides list
- By nuclides database

By the List of Identified Nuclides

IdentInfoForm

Line energy / Nuclide	Line area / Energy	Activity / Nuclide	Activity / Energy	Fitting...
106.012	< 1100 (±)			
↓ 228.0	< 900 (±)			
↓ 236.01	< 1100 (±)			
↓ 251.484	< 800 (±)			
Eu-152 13.5...	251.63 (±0.007)	5814.3 (±)		
↓ 259.105	< 700 (±)			
↓ 271.024	< 900 (±)			
Eu-152 13.5...	271.131 (±0.008)	7564.9 (±)		
↓ 315.209	< 680 (±)			
Eu-152 13.5...	315.174 (±0.017)	8934.7 (±)		
↓ 405.372	470 (±220)			
↓ 436.958	460 (±220)			
Np-231 4...	436.9 (±0.4)	2255.6 (±)		
Er-149M ...	436.7 (±0.1)	163.0 (±)		
Sc-42M ...	437.5 (±0.5)	6.4 (±3)		
Md-255 2...	430.0 (±40.0)	79.2 (±)		
↓ 438.846	470 (±210)			
↓ 452.319	< 500 (±)			
↓ 508.907	1010 (±240)			
↓ 512.439	< 900 (±)			
Am-241 432.2...	512.5 (±0.3)	701462154.7 (±)		

Line energy	Energy error	Intensity	Intensity error	Line t...
44.800	0.100	0.000	0.000	G
370.900	0.300	9.800	9.801	G
376.300	0.400	0.637	0.638	G
416.300	0.300	0.284	0.290	G
420.700	0.400	1.049	1.054	G
436.900	0.400	0.284	0.290	G
481.600	0.500	0.608	0.619	G
511.003		0.200		An
737.800	0.300	1.235	1.237	G
786.600	0.300	0.186	0.186	G
851.600	0.500	0.696	0.696	G
1108.100	0.300	0.539	0.541	G

By all nuclides in database

Identification window (keV): 0.2

Nuclides decay chain

Maximal activity: 1.0E+8

Meas. date: 09-06-2008 12:53:27

T1: 1.21E+08 Years

22 марта 2007 г. 16:36:41

T2: 2.59E+0 Months

22 марта 2008 г. 16:36:16

Filter by chain

Scan spectrum Joint identification

Identify line 436.958 keV

Identify all lines

Settings >>

Get lines for Np-231

Add to library

Close

Extension of Nuclides Library Filter by Energy

The screenshot displays the 'IdentInfoForm' software window. The main area contains a table with the following columns: 'Line energy / Nuclide', 'Line area / Energy', 'Activity / Nuclide', and 'Activity /'. The table lists various nuclides with their respective half-lives, line areas, and activities. The nuclide **Po-210** is highlighted in yellow.

Line energy / Nuclide	Line area / Energy	Activity / Nuclide	Activity /
<input checked="" type="checkbox"/> V-48 15.97(day)	803.25 (±0.08)	565989.77 (±130000)	
<input type="checkbox"/> Hg-193M 11.8(hour)	803.22 (±0.25)	2209285.2 (±1000000)	
<input type="checkbox"/> At-203 7.4(min)	803.2 (±0.2)	17084.65 (±3000)	
<input type="checkbox"/> Tl-206 4.2(min)	803.3 (±0.2)	16977283.03 (±4000000)	
<input type="checkbox"/> Te-133 12.5(min)	803.3 (±0.3)	647790.10 (±150000)	
<input type="checkbox"/> Ho-150M 23.3(sek)	803.3 (±0.2)	853.04 (±160)	
<input type="checkbox"/> Po-210 138.38(day)	803.1 (±0.01)	70137764.47 (±130000000)	
<input type="checkbox"/> Pb-206M 1.3E-04(s...)	803.1 (±0.1)	857.24 (±160)	
<input type="checkbox"/> Bi-206 6.24(day)	803.1 (±0.05)	858.11 (±160)	
<input type="checkbox"/> Bi-196M 4.0(min)	803.1 (±0.5)	264758.3 (±140000)	
<input type="checkbox"/> Ba-124 11.0(min)	803.4 AP	3537344.8 (±)	
<input type="checkbox"/> As-83 13.4(sek)	803.4 (±0.2)	27140.75 (±6000)	
<input type="checkbox"/> Tm-163 1.81(hour)	803.469 (±0.022)	316991.78 (±60000)	
<input type="checkbox"/> Tb-150 3.48(hour)	803.0 (±1.0)	2357134.30 (±700000)	
<input type="checkbox"/> Sn-107 2.9(min)	803.0 (±1.0)	13469.34 (±2500)	
<input type="checkbox"/> Mo-89 2.11(min)	803.0 (±1.0)	93972.13 (±18000)	
<input type="checkbox"/> Ba-129M 2.16(hour)	803.0 (±0.1)	9959.72 (±1900)	
<input type="checkbox"/> Th-227 18.72(day)	803.5 (±0.2)	92039170.67 (±220000000)	
<input type="checkbox"/> Ru-109 34.5(sek)	803.5 (±0.5)	428818.9 (±200000)	
<input type="checkbox"/> Br-86 55.0(sek)	803.5 (±0.3)	30151.3 (±9000)	
<input type="checkbox"/> Br-76 16.2(hour)	803.5 (±0.2)	161602.85 (±30000)	
<input type="checkbox"/> Yb-163 11.05(min)	802.96 (±0.15)	101015.3 (±30000)	
<input type="checkbox"/> Gd-149 9.28(day)	802.94 (±0.02)	1977969.10 (±400000)	
<input type="checkbox"/> Te-133 12.5(min)	802.9 (±0.3)	1359727.2 (±500000)	
<input type="checkbox"/> Ba-130M 9.4E-03(s...)	802.9 (±0.5)	9769.37 (±2100)	
<input type="checkbox"/> Ag-121 0.78(sek)	803.58 (±0.1)	132264.83 (±28000)	
<input type="checkbox"/> Re-181 19.9(hour)	803.6 (±0.4)	57375.7 (±30000)	
<input type="checkbox"/> Dy-155 9.9(hour)	802.87 (±0.06)	4961638.39 (±1100000)	

The right-hand panel contains control options:

- By all nuclides in database
- Identification window [keV]: 1.0
- Nuclides decay chain
- Maximal activity: 1000
- Meas. date: 01-07-2008 19:25:20
- T1: 0.0E+0 Years
- T2: 0.0E+0 Years
- Filter by chain
- Scan spectrum
- show PDV
- show sum peak
- show DB data
- Identify line 803.239 keV
- Identify all lines
- Show identified lines
- Show unidentified lines
- Activity units: Bq
- Get lines for Po-210
- Add to library
- Close

Extension of Nuclides Library Filter by Half-life Period

IdentInfoForm

Line energy / Nuclide	Line area / Energy	Activity / Nuclide	Activity / Energy	Fitting criteria / ...
<input checked="" type="checkbox"/> 803.025	144 (±24)			
<input checked="" type="checkbox"/> Po-210 138.38(day)	803.1 (±0.01)	470984948.16611	Po-210 138.38(day)	01-07-2007 19...
<input type="checkbox"/> Po-210 138.38(day)	803.1 (±0.01)	92061274.876896	Pb-210 22.3(year)	01-07-2007 19...
<input type="checkbox"/> Bi-206 6.24(day)	803.1 (±0.05)	49893225.686877	Fr-210 3.18(min)	01-06-2008 19...
<input type="checkbox"/> Bi-206 6.24(day)	803.1 (±0.05)	889792572.454833	Ac-214 8.2(sek)	01-06-2008 19...
<input type="checkbox"/> Bi-206 6.24(day)	803.1 (±0.05)	440806.139377	Rn-210 2.4(hour)	01-06-2008 19...
<input type="checkbox"/> Bi-206 6.24(day)	803.1 (±0.05)	25759.992504	Bi-206 6.24(day)	01-06-2008 19...
<input type="checkbox"/> Bi-206 6.24(day)	803.1 (±0.05)	4850.072138	Po-206 8.8(day)	01-06-2008 19...
<input type="checkbox"/> Bi-206 6.24(day)	803.1 (±0.05)	2063403.632578	At-206 30.0(min)	01-06-2008 19...
<input type="checkbox"/> Bi-206 6.24(day)	803.1 (±0.05)	257567213.938986	At-210 8.1(hour)	01-06-2008 19...
<input type="checkbox"/> Gd-149 9.28(day)	802.94 (±0.02)	19962614.522934	Gd-149 9.28(day)	01-06-2008 19...
<input type="checkbox"/> Tl-206 4.2(min)	803.3 (±0.2)	18226735.504319	Bi-210M 3.0E+06(...)	01-07-2007 19...

Line energy	Energy error	Intensity	Intensity error	Line t...

By all nuclides in database

Identification window (keV): 0.1

Nuclides decay chain

Maximal activity: 1.0E+9

Meas. date: 01-07-2008 19:25:20

T1: 1.0E+0 Years

show POV show PDV

show sum peak show DB data

Identify line 803.025 keV

Identify all lines

Show identified lines

Show unidentified lines

Activity units: Bq

Get lines for Po-210

Add to library

Close

Extension of Nuclides Library Filter by Spectrum

IdentInfoForm

Line energy / Nuclide	Line area / Energy	Activity / Nuclide	Activity / Energy	Fitting criteri...
<input checked="" type="checkbox"/> 803.239	134 (±23)			
<input checked="" type="checkbox"/> TI-206 4.2(min)	803.3 (±0.2)	16977283.03 (±4000000)		
<input type="checkbox"/> Po-210 138.38(day)	803.1 (±0.01)	70137764.47 (±13000000)		

Line energy	Energy error	Intensity	Intensity error	Line t...

By all nuclides in database

Identification window (keV): 1.0

Nuclides decay chain

Maximal activity: 1.0E+10

Meas. date: 01-07-2008 19:25:20

T1: 1.0E+0 Years

1 июля 2007 г. 19:25:20

T2: 1.0E+0 Days

30 июня 2008 г. 19:25:20

Filter by chain

Scan spectrum

show PDV show PDV

show sum peak show DB data

Identify line 803.239 keV

Identify all lines

Show identified lines

Show unidentified lines

Activity units: Bq

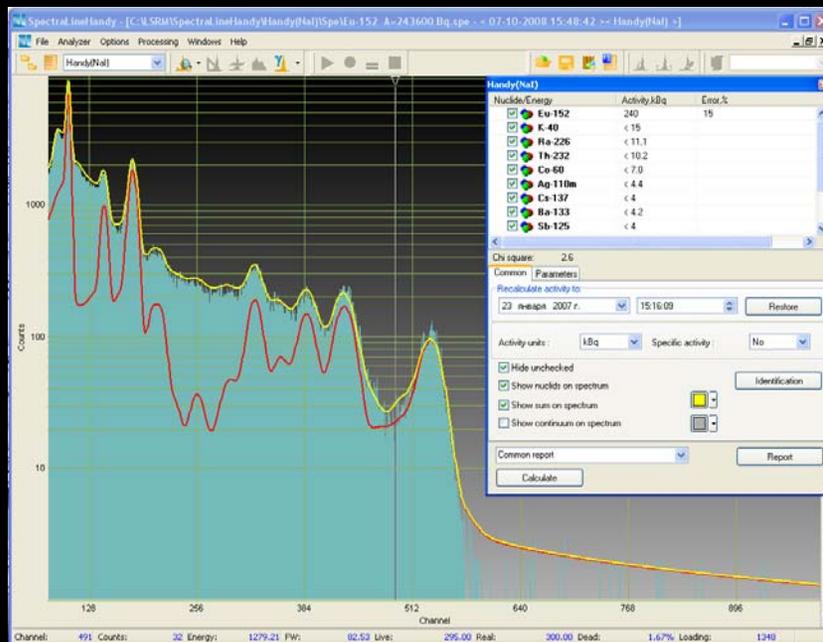
Get lines for Po-210

Add to library

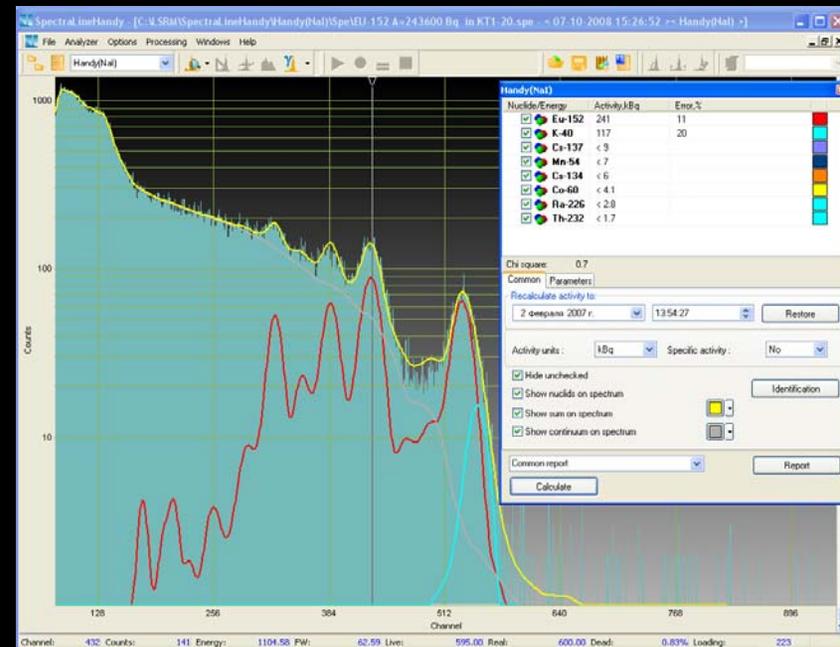
Close

“Quasi-Reference Spectra” Method for Spectrometers with Low Resolution

Spectrum of Eu-152 point source measured with NaI-detector



Eu-152 in container KT1-20, measured with NaI-detector



Our Software Nowadays

- Peaks search procedures with high functionality
- Procedures of identification and activity calculation using intensities ratio and absorption in the container material
- Software with comprehensive data: database of nuclides with their decay chains, database with cross sections of material-radiation interaction

Software Development

Methodological and algorithmic tasks

- Limitation of nuclides library, nuclides classification depending on their co-presence
- Using information about available nuclides to restore calibration, analyze absorption etc.
- Development of procedures for estimation of radiation absorption based on the approximate information about matrix or container properties

Technical tasks

- Duplication of mouse functions by shortcut keys
- Support of the main spectra formats



**LABORATORY
of spectrometry
and radiometry**

<http://www.lsrn.ru>
mail: lsrn@lsrn.ru
Phone: +7 495 660-16-14

Thank you for your kind attention!